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ONTARIO

Department of Education

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Courses of Study

in

Grades IX, X, XI, and XII

leading to the

Secondary School Graduation Diploma

of

THE INDUSTRIAL COURSE

These revised courses introduced in September 1955 replace those formerly contained in Tech. 17 (1943), Science, and Tech. 40 (1946), Shop Courses. The Courses in Mathematics outlined herein are to be used instead of those contained in Curriculum S. 12, Mathematics. The courses herein for Social Studies, History of Industry, and Elements of Economics are the same as those outlined in Circular I. and S. 8 (1954), Commercial Courses.

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TABLE OF CONTENTS

	Page
1. General Information regarding the Organization of the Industrial Courses.....	3
2. English.....	6
3. Social Studies.....	6
History of Industry.....	6
Elements of Economics.....	8
4. Mathematics.....	9
5. Science.....	17
6. Major Shop Work Courses.....	29
Aircraft.....	30
Applied Electricity.....	36
Applied Electronics.....	41
Auto Mechanics.....	45
Drafting, Grades IX and X.....	50
Drafting, Architectural and Building Construction.....	52
Drafting, Mechanical.....	55
Industrial Chemistry.....	58
Machine Shop Practice.....	62
Printing.....	65
Sheet Metal.....	68
Welding.....	71
Woodworking.....	77
Farm Mechanics.....	85
7. Related Shop Work Courses.....	89

THE INDUSTRIAL COURSE

The Industrial Course includes a number of full-time day courses covering a four-year programme of education leading to a Secondary School Graduation Diploma.

The courses are designed to give

- (a) the foundations of a general education as a basis of good citizenship, and
- (b) specialized basic training in the subjects, processes, and operations in the fields of work and industry to which the school concerned is most closely related.

The following division of time between the academic and shop work subjects is suggested.

<u>Grade</u>	<u>Academic Subjects</u>	<u>Shop Work Subjects</u>
IX	75%	25%
X	65%	35%
XI	55%	45%
XII	55%	45%

The first two years of shop work are exploratory in nature; that is, the pupils are given instruction in all or most of the shop work subjects. This gives the teachers an opportunity to ascertain the special aptitudes, capacities, and interests of the individual pupil, and enables the pupil to make an intelligent selection of the shop work subjects in which he wishes to complete the training in Grades XI and XII preparatory to his admission to a trade or industry.

The pupil may obtain the Secondary School Graduation Diploma of the Industrial Course in any one of the following specialized shop work subjects, and the diploma will indicate the course completed.

AIRCRAFT MECHANICS	PLASTICS
APPLIED ELECTRICITY	PLUMBING
APPLIED ELECTRONICS	PRINTING
AUTO MECHANICS	SHEET METAL PRACTICE
DRAFTING—ARCHITECTURAL AND BUILDING CONSTRUCTION	TAILORING
DRAFTING—MECHANICAL	WATCH MAKING
ELECTRICAL AND STEAM OPERATING	WELDING
FINE INSTRUMENT PRACTICE	WOODWORKING—CABINET-MAKING
FOUNDRY PRACTICE	WOODWORKING—CARPENTRY
INDUSTRIAL CHEMISTRY	WOODWORKING—GENERAL
MACHINE SHOP PRACTICE	WOODWORKING—PATTERNMAKING
MINING	INDUSTRIAL—SPECIAL (see Note 1)

NOTE 1:—This course consists of one full year of study with a programme consisting of 75% practical work and 25% of related English, Mathematics, and Science. The entrance requirement for this course is the successful completion of Grade XI in any secondary school course. (See page 5).

Pupils who have completed these courses with standing satisfactory to the principal may proceed to Grade XIII to qualify for admission to the universities. Where a foreign language is required for a specific purpose such as University entrance the pupil will need to acquire the basic knowledge represented by Grade XII standing in the language before he undertakes the Grade XIII study of this subject.

Allotment of Time to the Subjects

The time allotment in the following table, taken from Circular H.S.1, is suggested as most suitable for a 40-period week.

Subjects	GRADE IX	Periods per Week
English.....		6
Social Studies.....		6
Physical Education.....		4
Mathematics.....		5
Guidance (Occupations).....		2
Science.....		5
Shop Work including Drafting.....		12

NOTE:—If Art or Music is offered, it will be necessary to reduce the time of the other subjects
Instrumental Music may be offered as a Shop Work subject.

GRADE X

English.....	7
Social Studies.....	5
Physical Education.....	4
Mathematics.....	5
Science.....	5
Shop Work including Drafting.....	14

NOTE:—Any one of Art, Music, Business Practice, or French may be substituted for four periods of Shop Work.

GRADES XI AND XII

English.....	5
History of Industry (Grade XI) }	4
Elements of Economics (Grade XII) }	
Physical Education.....	4
Mathematics.....	5
Science.....	4
Shop Work:	
Major Shop.....	10
Related Shops (two).....	8

NOTE:—Any one of Art, Music, Commercial Work, or French may be substituted for four periods of Shop Work.

MODIFIED COURSES

In addition to the regular four-year Industrial Course, the following courses, which are offered in some schools, are designed to meet particular conditions.

1. TWO-YEAR TERMINAL TRADE COURSES

In these courses one half of the pupil's time is devoted to the study of academic subjects, and the balance to shop work subjects. In Grade IX the shop work is exploratory and covers a number of shop subjects; in Grade X the pupil may specialize in a shop of his choice. A pupil who completes successfully a two-year course of this type will be granted an Intermediate Certificate.

The pupil may transfer to a regular four-year Industrial Course with a credit of one year, or he may enter into an apprenticeship in the trade in which he has specialized, and be given a time credit for his school work.

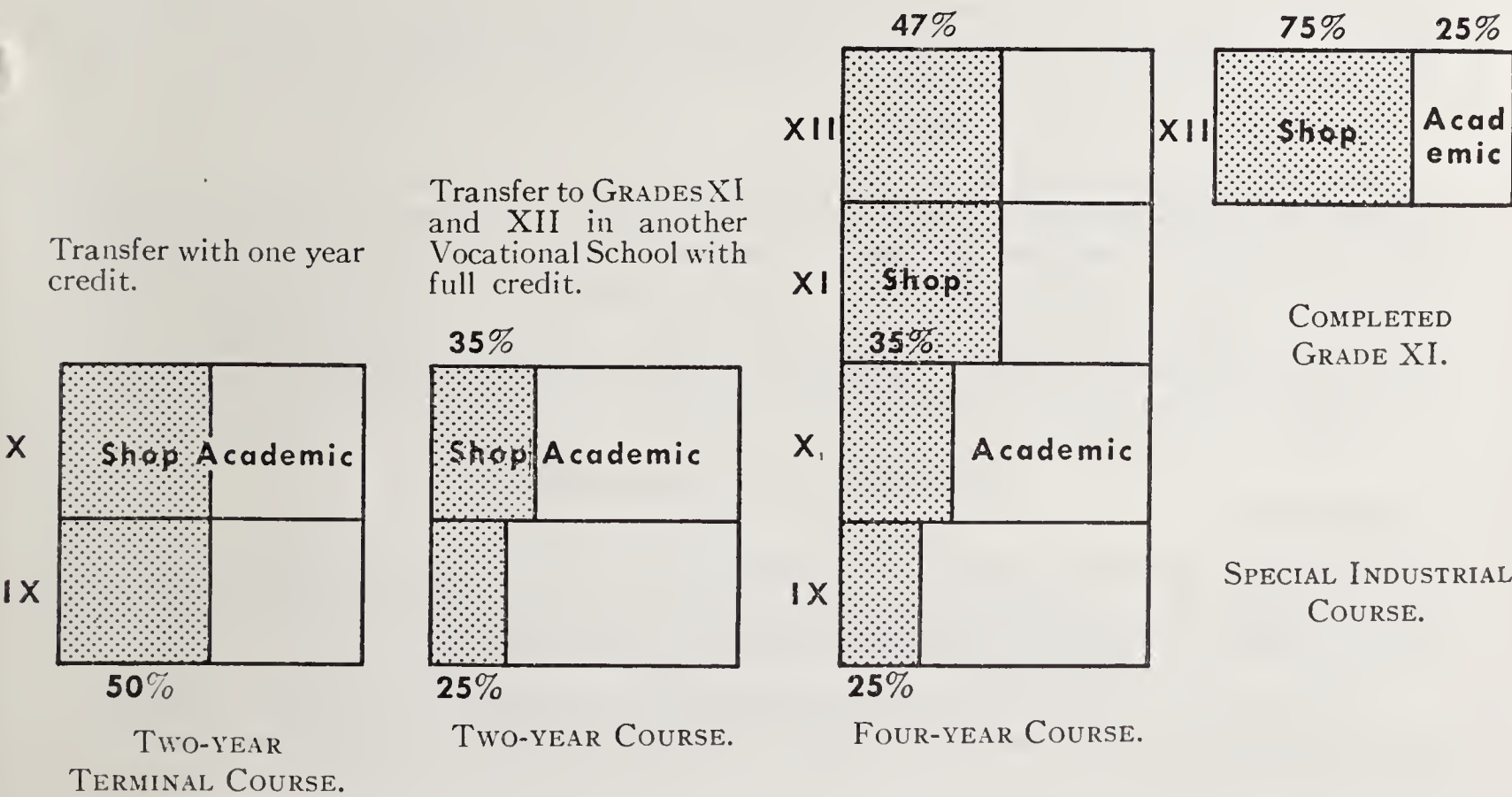
2. TWO-YEAR COURSES

These courses are designed for a school which offers only two years of the four-year Industrial Course. The allotment of time and the subjects studied are the same as in the regular four-year Industrial Courses, except that the shop work courses may be modified to meet local conditions. A pupil completing Grade X of one of these courses will be granted an Intermediate Certificate and may transfer to another vocational school for specialization in a particular shop work subject in Grades XI and XII.

3. SPECIAL INDUSTRIAL COURSE

This is a one-year course in which 25 per cent of the pupil's time is devoted to the study of academic subjects, and 75 per cent to shop work subjects. A pupil may be admitted to this course who has successfully completed at least three years of study in any secondary school course other than the Industrial Course. A Secondary School Graduation Diploma may be granted upon the successful completion of this course.

GRAPHICAL ILLUSTRATION OF THE COURSES DESCRIBED ABOVE



ENGLISH

English is vital to the general development of the pupil and is, therefore, the direct concern of every teacher. Adequate skill in the use of English is essential to progress in all subjects of the curriculum, to success in meeting the practical demands of everyday life, and to fulfilment of the duties of citizenship in a democracy. Its importance to pupils who plan to enter industrial life cannot be over-emphasized.

An outline of the complete programme in English, grades IX and X, is contained in Curriculum I.1, "Intermediate Division, Outlines of Courses for Experimental Use." This course consists of a study of Literature and Composition. The work in Literature includes the study of prose, plays and poetry in which oral reading and comprehension are stressed. In addition to the books which are studied in class, the pupil is required to read at least six books each year consisting of works of fiction, non-fiction, poetry and drama. The study of Grammar is included in the work in Literature and Composition, and in the latter, the aim is to train the pupil to express his thoughts in good form. In grades XI and XII, the course will be similar to that of the General Course as outlined in Curriculum S.4. In all grades, the teacher is expected to select texts and books of particular significance to the interests of the pupils in the different classes.

One of the objectives of this course should be to teach the pupils to write business letters, précis of technical articles, and concise reports. Some of the supplementary reading should be on scientific and industrial topics and should include biographies of scientists, inventors, and industrial leaders.

There are many ways in which the importance of English to the shop work subject can be emphasized. For example, the assignment of a précis, or a report on a shop work topic, can be marked by the shop work teacher for technical content, and also by the English teacher for composition.

SOCIAL STUDIES

In grades IX and X, social studies is an integration of the history and geography of particular areas. In grade IX the suggested course is "Canada and the Americas"; in grade X, "Canada and the Modern World." These courses are outlined in Curriculum I.1, "Intermediate Division, Outlines of Courses for Experimental Use."

In grades XI and XII of the Industrial Course, the subjects are, respectively, History of Industry and Elements of Economics. In these courses a limited study is made of the geographical, economic, and social factors in the development of various aspects of commerce and industry. Particular attention is paid to the economic development of Canada, and the basic principles of economics are related, wherever possible, to the phenomenal growth of Canada's trade and industry in the twentieth century.

HISTORY OF INDUSTRY

Suggestions

Since the course in History of Industry deals with a period stretching from the beginning of recorded civilization to the economic and commercial development of modern Canada, detailed treatment is impossible.

Part I of the course should be completed by the end of January to permit a careful study in the second half of the year of several aspects of Canadian economic development.

The first unit of Part I should focus attention on the geographic factors underlying the economic development of the ancient civilizations, and should indicate the major achievements of each. Every effort should be made to excite the interest and curiosity of the pupils and to encourage supplementary reading of books related to the period.

Throughout the course there are many opportunities for making interesting comparisons to illustrate the similarities and differences between the past and the world which the pupils know today. The following examples suggest types of problems which might be undertaken:

- (a) a comparison of the development of ancient Phoenicia and modern Britain as seafaring, trading and colonizing nations;
- (b) a comparison of the type of agriculture practised on the medieval manor with that of a modern Saskatchewan farm;
- (c) a comparison of craft guilds and modern trade unions;
- (d) a comparison of the achievements of the sailors of the exploration period with those of the aviators of the modern era;
- (e) a comparison of working conditions in the early factories of Great Britain with those in modern factories.

The course in History of Industry offers excellent opportunities for pupils to develop their powers of expression, both written and oral. Reports should be prepared, based upon the investigations of specific problems. They should be checked carefully by the teacher both for accuracy of content and for good literary style. Oral reports may be presented by committees of pupils who have co-operated in the investigation of a problem. Debates may be used effectively in the treatment of certain topics.

Part I (First half-year)

1. Commerce in the Ancient World: a brief consideration of the resources, products, and principal commercial achievements of Egypt, Babylonia, Greece, Phoenicia, and Rome; map work to indicate areas of colonization and principal trade routes of the ancient world.
2. The Medieval Period: the manorial system; town and country life; industry and commerce; the fairs; the influence of the Church and the Crusades; the Hanseatic League; the trade guilds; the craft guilds.
3. The Period of Explorations: the great explorers and their discoveries; the effects of their discoveries; European colonies in the new world (compare with conditions today); trading companies, such as the East India Company and the Hudson's Bay Company; the Mercantile System.
4. The Period of Revolutions: the inventions and discoveries which made possible the revolutions in agriculture, industry, power development, transport, and communication; development from the handicraft system to the factory system; the evils of the factory system; corrective legislation.
5. Modern Production and Distribution: large scale production; need for increased capital; growth of joint stock companies; development of stock and commodity exchanges; changes in retailing; co-operatives; growth of international trade.

Part II Canadian Development (Second half of year)

1. Canadian population and immigration; the French settlers; people from the British Isles; the Homestead Policy; vigorous immigration under Laurier; oriental immigration; immigration between the world wars; New Canadians following World War II; statistical studies of the growth of population.
2. The evolution of transport in Canada; early waterways; roads and highways; canals; railways; automobiles and trucks; aviation.

3. Growth of Canada's industries; the fur trade; fishing; lumbering; ship-building; agriculture; growth of our industries in recent times; wheat and the grain trade; light and power, iron and steel, aluminum, petroleum in the West, newsprint, nickel, other industries of local importance.
4. Canada's foreign trade; foreign trade under the French régime; changes under British rule; tariff developments in Canada, early tariffs; free trade with the United States in 1854; National Policy of Macdonald; preferences under Laurier; our chief imports and exports today; direction of our foreign trade.
5. Crises and booms in Canadian economic development; the nineteenth century; the two world wars and their effects.
6. Canada's place in world affairs today; her place in the British Commonwealth; her place in the United Nations and NATO; the Colombo Plan; Canada's relationship with the United States.

ELEMENTS OF ECONOMICS

Aims

1. To promote a better understanding of the economic factors governing Canada's development.
2. To develop the fundamental economic principles which are basic to intelligent citizenship and effective daily living.
3. To encourage reading, reasoning and discussion in the development of sound economic judgments.

Course of Study

1. A review of Canada's important industries and transportation systems to illustrate the nature of modern production; the economic factors of production; large-scale production, its advantages and disadvantages; monopoly organization of production enterprises—single proprietorship, partnership, corporation, co-operation, government enterprise.
2. Canada's national income; elements of distribution; rent, wages, interest, and profits. (Studies of distribution in the case of individual firms can be made through examination of the annual reports of Canadian corporations.)
3. How Canadians consume and save; laws of consumption, unwise consumption; budgeting; buying for cash or on credit; saving and investing; savings accounts; life insurance and annuities; bonds; stocks; real estate and real estate mortgages.
4. Exchange: the price system; the law of supply and demand; different ways in which prices are established; the use of index numbers.
5. The rise of Canada's monetary system: card money in French Canada; Spanish, French and English currency; Canada adopts the decimal system; qualities of a good money system; functions of money; Canada's commercial banks and how they operate; the Bank of Canada; trust companies, finance companies and credit unions; the place of gold in our economy; inflation and how it affects us.
6. International trade and foreign exchange; Canada's import and export trade; the tariff system; arguments for free trade and protection; Canadian exchange rates.
7. The rise of the labour movement in Canada; American influences; Railway Brotherhoods; Trades and Labour Congress; the Canadian Congress of Labour; Canadian and Catholic Confederation of Labour; labour leaders and programmes; labour problems—unemployment, accidents, sickness, and old age.

8. Social security laws and labour legislation: federal laws—Industrial Disputes Act, old age pensions, pensions for the blind, unemployment insurance, family allowances; provincial laws—child labour, maximum hours, minimum wages, workmen's compensation, mothers' allowances.
 9. Governments in economic life: expenditures of federal, provincial and municipal governments; the national debt; the sources of public revenue; theories of taxation; direct and indirect taxation; Canada's tax system.
 10. A brief comparative study of the economic organization under systems of capitalism, fascism, socialism, and communism.
 11. An individual or group investigation of a Canadian economic problem; at the present time the St. Lawrence Deep Waterway and Power Project would be a suitable topic.
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MATHEMATICS

General Observations

1. Suggested outlines of the work to be followed in the various grades are provided below, but these may be changed or supplemented where necessary to meet local requirements.
2. The courses are based on five periods of forty minutes duration per week. To permit some selection, more topics have been included than can normally be covered in this time.
3. It is expected that the items designated in the courses as "optional" will be included in the work taken with above-average classes, or in the assignments given to the better students within a class group of varying ability.
4. In planning the courses for Grades XI and XII, consideration has been given to the fact that most of the pupils from the Industrial Course go directly to industry. However, some pupils do proceed with advanced technological training and therefore some consideration has been given to the needs of these pupils. In most cases, the practical applications of theoretical topics have been shown, although it is believed that some mathematics may be taught for the development of mathematical skill alone. Some topics should provide for necessary drill while others are included to supply practice in methodical arrangement of work which will lead to logical reasoning.

Aims of the Courses

1. To give a good basic training to those pupils who leave school at the end of Grade X or Grade XII respectively as well as to those who will continue their formal education.
2. To stress the fundamentals of Mathematics so that the student will be able to solve normal mathematical problems arising in the shops or in a practical field of work.
3. To motivate the student by correlating the content of the course with related subjects where possible and also by correlating related phases of Mathematics.
4. To provide training in citizenship, one of the important phases of education, by developing habits of thought such as sound reasoning, clear thinking, use of judgment, powers of concentration, and by developing work habits such as neatness, accuracy, initiative, perseverance, self-reliance.

GRADE IX

Instead of beginning with an extensive review of the fundamental operations involving integers, and common and decimal fractions, and then proceeding to the other arithmetical topics in regular order, it is suggested that the year's work might begin with three periods a week in Experimental Geometry and two in Measurement. Practice in the fundamental skills of Arithmetic should be spread throughout the year and should be obtained by frequent systematic oral and written drill. The necessary practice in the fundamental operations should be made a regular feature of the Mathematics lessons. It should not be haphazard or impromptu, but should be consciously aimed at correcting the weaknesses discovered.

1. *Practical Geometry*

Definitions: angle, vertex, and arms of an angle.

Classification: right, acute, straight and obtuse.

Construction and measurement of angles by protractor: unit of measurement, the degree.

Sum of the angles in any triangle derived by measurement, and demonstrated experimentally.

Relation of arc and sector to angle at centre of circle.

Exercises reviewing the mensuration of the circle.

Geometric constructions: parallel lines, equilateral, isosceles, scalene and right-angled triangles; bisecting a given line; bisecting a given angle; erecting a perpendicular to a line; constructing squares and rectangles.

2. *Arithmetic*

The Arabic system of numeration, the decimal point.

Fundamental operations of addition, subtraction, multiplication, division (long and short) of: (i) integers, (ii) vulgar fractions, (iii) decimal fractions; useful short methods of calculation; factoring and tests for factors: 2, 3, 4, 5, 6, 9, 11; square and cube root by factors.

H.C.F. and L.C.M.

Order of operations in problems, use of brackets, "of" sign.

Practice in expressing vulgar fractions and mixed numbers in decimal notation and converse problems.

Percentage, meaning and use in problems.

Changing decimal and vulgar key fractions such as $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$ to percentages; and converse problems.

Significance of digits in numbers obtained by measurement and in numbers obtained in calculation from measurements. Rounding off decimal fractions and computation with approximate numbers.

Methods of checking—including estimation, casting out nines.

Simple practical problems using the fundamental operations of this unit.

Supplementary Topics

History of Arabic system of numeration.

Roman and other systems; methods of performing fundamental operations in these systems.

Measurement

Use of scales graduated in inches and tenths, inches and sixteenths, feet and inches, and feet and tenths of a foot.

English units of length; history of these units.

Metric units of length (linear); history of the metre.

Construction and measurement of straight lines; use of dividers (or compasses) in transferring lengths; addition and subtraction of line segments.

Measurement of longer distances with (i) yard stick, (ii) two-foot rule, (iii) 25 or 50-foot tape.

Tables of square measure (common units).

Areas and perimeters of squares, rectangles.

Conversion from English to metric linear units and vice versa.

Practical problems using both English and Metric linear units, using integers, fractions and decimals, and stressing the advantage of decimal notation in computation.

Scale drawings based on rectangle and square.

Supplementary Topics

History and meaning of other units of length: cubit, span, fathom, nautical mile, etc.

3. *Algebra*

Introduction and use of general number.

Simple equation: development; solving by (i) axioms, (ii) transposition; verification.

Construction of simple equations and their solution applied to simple problems.

Use of a few equations with simple fractional, and decimal coefficients.

Formulae: changing verbal statements into formulae; interpreting simple formulae; evaluating formulae; construction of tables from formulae.

Use of index (positive integral).

Supplementary Topic

Graphs of simple formulae.

Directed Numbers

Use of plus and minus as signs of direction or quality.

Graphs of positive, zero, and negative numbers along a straight line; calculation of distances between two points on the same side or on opposite sides of zero for both integral and decimal notations.

Addition and subtraction of directed numbers (integral and decimal).

Multiplication and division of directed numbers (integral and decimal). Rule of signs developed.

Addition and Subtraction

Addition and subtraction of algebraic numbers not exceeding three terms.

Insertion and removal of brackets in problems involving addition and subtraction.

Checking algebraic additions and subtractions by substitution of numerical values.

Multiplication and Division

Multiplication and division of algebraic numbers: monomial by monomial (formulation of index laws and evaluating numbers expressed as powers of integers); binomials by monomials; binomial by binomial; two special cases—(a) sum by difference, (b) square of binomial.

Checking of products and quotients by substitution of positive and negative values.

Factoring

Common factor; difference of squares; perfect square of binomial.

Equations of First Degree

Solving simple equations of the first degree in one unknown; with positive and negative roots; containing brackets; containing simple fractional and decimal coefficients.

Translating statements into equations and equations into statements.

Applied problems involving the simple equation.

Transposition and translation of simple formulae, e.g. Ohm's law, levers, circle formulae, etc.

Supplementary Topic

Arithmetical and geometrical applications of factoring.

4. *Graphs*

Simple graph: bar graph; line graph; rectangular distribution graph; circular distribution graph.

GRADE X

1. *Mensuration and Arithmetic*

The necessity for repeated drills in fundamental operations, if those skills are to be maintained and improved, is recognized. It is felt that mental or mechanical drill in Arithmetic might be taken in some periods. As far as possible, topics should be reviewed or taught through shop problems. The pupils should receive much drill in the use of the decimal equivalent tables.

Arithmetic

Addition, subtraction, multiplication, and division of fractions through shop problems; practice in such operations as $\frac{47}{64} = \frac{3}{4} - \frac{1}{64}$ and similar examples; nearest ruler fraction.

Addition, subtraction, multiplication, and division of decimals; conversion of decimals to fractions and fractions to decimals; use of the table of decimal equivalents particularly with reference to the 64th scale; significant digits and the correct rounding off of decimals.

Use of the micrometer; mathematics of the scale, reading the scale, making of settings.

Use of the Vernier: 1000th scale.

Measurement of Length

Calculation of perimeters of: square ($4s$); rectangle $2(1+w)$; triangle $(a+b+c)$ circle (πd or $2\pi r$); the value for π to be in accordance with the degree of accuracy required; cutting and surface speeds, feed of lathe and drills.

Measurement of Area

Formulae to be developed or illustrated where possible. Efforts should be made to use practical shop problems in this work.

Area of the square (s^2); formal method of square root in finding the side of a square from the area; the right-angled triangle and the relationship between the sides. Area of a rectangle (lw) extended to areas of various rectangular surfaces, use of square root in finding the length of diagonals; area of the parallelogram and the rhombus; area of the triangle; areas of triangular surfaces such as floors, fields, lots; use of the formulae: $A = \frac{1}{2}bh$

$$A = \sqrt{s(s-a)(s-b)(s-c)};$$

Area of the equilateral triangle, $A = .433s^2$;

Applications to the altitude of sharp V thread and the hexagon; area of the trapezium; areas of figures combining areas of a triangle and a rectangle or a triangle and a trapezium such as gables, templates; area of a circle, $A = \pi r^2$ or $.7854 D^2$, extended to capacity of pipes, pressure in cylinders; use of the formula

$D^2 = D_1^2 + D_2^2 + D_3^2$ to find the diameter of a pipe equal in capacity to several pipes; areas of combined figures.

Optional Topics

Area of the surface of rectangular objects; lateral area = ph ; area of walls, lateral area of buildings.

Area of the surface of a cylinder (ch); finding the number of square feet of metal in cylindrical tanks, pipes, and cans.

Volume

The table of cubic measure (common units).

The volume of rectangular and triangular forms and structures with uniform cross-section throughout; such as, tanks, reservoirs, and excavations.

The volume of cylinders ($\pi r^2 h$ or $.7854 D^2 h$): finding capacity of cylindrical tanks.

Board measure: meaning of, units of measurements, calculations.

2. Geometry

Points and Lines: review Grade IX work; practice in measuring, estimating, and constructing lines using English and metric units.

Angles: review Grade IX work; practice in measuring, estimating, constructing angles; relationships between units; changing 3.5° to $3^\circ 30'$, etc.

Types of angles: acute, right, obtuse, straight, reflex, complementary, supplementary.

Uses in some of the following: latitude, longitude, standard time, rotation, direction, mariner's compass, (32 points), bearings, surveyor's measure, gear teeth, taper, motor-timing, and threads.

Experimental determination of the relationships between vertically opposite angles, the sum of the angles in a triangle, exterior and interior, non-adjacent angles.

Numerical applications.

Triangles: construction and comparison of triangles to show congruency in the four cases—three sides, two sides and contained angle, two angles and corresponding side, hypotenuse and one side; classification according to sides and angles; special study of the properties of isosceles and equilateral triangles; study of two isosceles triangles on opposite sides of a common base to lead up to accurate construction.

Accurate Constructions; review and extension of the work of Grade IX.

The following constructions: Bisecting a given line; constructing right bisector; illustration by measurement—line joining mid-points of sides of a triangle = $\frac{1}{2}$ base; right bisector of a straight line is the locus of centres of circles passing through the ends of the straight line; family of circles through two given points; circumcentre and circumcircle in acute, obtuse, and right-angled triangles; medians; centroid divides median in ratio of 1:2; illustration of centre of gravity by cut-out triangle in cardboard, sheet metal, or plastic.

Bisecting a given angle: constructing bisectors of several angles of increasing size to develop method of drawing a perpendicular from a point inside a line; constructing special angles by bisections from 90° and 60° ; bisecting the three angles of a triangle to show that the bisectors are concurrent.

Constructing a perpendicular from a point outside a line: distance from a point to a line; altitudes of a triangle; the orthocentre; any point of the bisector of an angle is equidistant from the arms of the angle; constructing a family of circles to touch the arms of an angle; inscribing circles in all types of triangles; escribed circles.

Constructing an angle equal to a given angle using ruler and compasses only; constructing equiangular triangles and quadrilaterals.

Parallel lines: the relationships of angles formed by a transversal; parallelograms and related facts by measurement; rhombus—diagonals bisect each other at right angles; dividing a line into equal parts and in given ratio.

Regular polygons: construction of equilateral triangle, square, hexagon (circle method), octagon by 45° angle at centre of circle and from a square (half diagonal method), any polygon by use of angle at centre; sum of angles of polygon; the angles of a regular polygon.

Circle: locating centre of circle by bisecting chords; equal chords; angle in segment and in semi-circle; tangent properties; belts and pulleys.

The right-angled triangle: the Pythagorean law by measurement of squares; calculation of sides of right-angled triangles; whether given sides form a right-angled triangle.

3. *Ratio and Proportion*

A study of simple ratios between measures, such as weights, volumes, distances, etc.

Scale drawing: similar triangles; ratios of corresponding sides; numerical problems; discovery, by measurement and calculation, that the ratio of pairs of sides in right-angled triangles is constant for a given angle.

4. *Algebra*

Review of algebraic notation and of the four fundamental operations.

Review of solutions of equations of the first degree in one unknown. Examples with integral, fractional, and decimal coefficients; graded problems requiring the solution of these equations.

Review and extension of factoring to include the following types: polynomials in which a common factor is obtained by inspection or by grouping of terms; trinomials with binomial factors; perfect square; difference of squares; polynomials which reduce to the difference of squares on completing a square.

Algebra applied to formulae from the shops: tapers; threads; pulleys and simple gear trains; gear calculations (using given formulae); resistances in series and parallel.

GRADE XI

1. *Index Laws*

Extension to include fractional, zero and negative indices; use of standard form to express very large or very small numbers to required degree of approximation; operations with standard numbers.

2. *Logarithms*

Definition of a logarithm; use of logarithmic tables; use of logarithms for multiplication, division, powers, and roots; problems, mensuration, formulae, etc.; use of logarithmic calculation to facilitate solving these problems.

3. *Slide Rule*

(a) Simple operations of multiplication, division, powers, roots.

(b) Combined operations: use of slide rule for computations involved in solutions of problems of mensuration, ratio, proportion, etc.

4. *Mensuration*

Development and algebraic manipulation of formulae along with the practical use of formulae. Facility in the use of the slide rule can be developed by using it to check answers in this section.

A. Surface Measurement

Review perimeters and areas of rectilinear, triangular and circular figures through practical problems and the manipulation of formulae; review the right triangle.

Areas: the circular sector; the circular ring; the segment of a circle; the curved surface of a cylinder.

Lateral and total surface area of a cone; lateral area of a frustum of a cone; the surface area of a sphere; perimeter and area of an ellipse; areas of regular polygons, finding the side of a regular polygon; lateral surface area of a pyramid and the frustum of a pyramid.

B. Measurement of Volume

Review of underlying principles and calculation of volume of prisms and cylinders.

Solution of practical problems based on prisms such as tanks, cylinders, castings, foundation walls, etc.; use of tables of density to determine weights; expressing volumes in various units of capacity; volume of cones, spheres, pyramids, castings; the solving of formulae for any one measurement; content of a partly-filled tank; volume of a frustum of a cone; problems on areas and volumes.

5. *Trigonometry*

Introduction: practical use in mathematics of navigation, surveying, machine design, and other fields.

The Right-Angled Triangle

The functions of the angles: sine, cosine, tangent; practice in writing the ratios for right-angled triangles of given dimensions; construction of right triangles to determine ratios for given angles and to determine angles having a given ratio; use of simplified tables; use of the unit circle to show variation in values from 0° to 90° for the different functions; simple problems involving the calculation of unknown distances or angles.

6. *Algebra*

A. Review

Fundamental operations including the laws of signs and exponents; simple equations with decimals and fractions involving transposition, cross multiplication and clearing of decimals and fractions; applications to Pythagorean theorem and practical problems.

B. Simultaneous Linear Equations

Graphical solution; elimination by substitution; elimination by addition or subtraction; applications to practical problems with two unknowns.

C. Multiplication and Factoring

Multiplication and squaring of binomials extended to include trinomials; factoring; (common monomial factor) a perfect trinomial square, the difference of two squares, a simple trinomial; arithmetical applications.

7. *Synthetic Geometry (optional)*

Note: Some work on formal proofs might be done at this stage.

A. The Circle

Definition and meaning of the terms related to the circle: sector, segment, arc, semi-circle, tangent, secant, concentric circle, the locus.

To draw a circle through three points; to find the centre of a circle, given an arc; to circumscribe a circle about a triangle, and vice versa; to inscribe a circle

in a triangle, and vice versa; to compare angles in a circle; to inscribe a circle inside or outside of a regular polygon; to draw a direct common tangent, and a transverse common tangent to two given circles; to draw circles tangent to lines and circles.

The application of the above to practical problems.

B. Areas of similar figures

To construct: a parallelogram equal in area to a triangle; a triangle equal in area to a trapezium, pentagon, etc.; a square equal in area to the sum of three squares; to divide geometric figures into any number of equal parts.

The application of the above in designs of mosaics, crests, posters, etc.

GRADE XII

The selection and the order of the topics should be chosen to suit the local requirements.

1. *Algebra*

A. Review of Grade XI Algebra

B. Simple Surds

Mixed and entire; addition of like surds; multiplication and division; tables of approximate values; rationalizing the denominator.

C. Quadratic Equations

Solving by: graphic method; factoring method; completing the square; quadratic formula.

Applications to Pythagorean theorem and problems relating to machine shop and tool and die design, involving the right triangle.

2. *Trigonometry*

A. The Right-Angled Triangle

Review simple trigonometry (Grade XI).

Reciprocal ratios: cotangent; secant and cosecant; use of tables; ratios of common angles e.g. 30° , 45° , and 60° , complementary ratios; limit ratios; simple basic formulae: e.g. $\tan x^\circ = \frac{\sin x^\circ}{\cos x^\circ}$

General review: practical problems involving the right triangle pertaining to gauges; V-blocks, dovetail sections; die sections and die punches, etc.

B. Angles greater than a right angle

Quadrants and co-ordinates.

Definitions; changes in the signs of the functions for the quadrants; simple rules for finding the ratios of angles between 90° and 360° ; drawing the graphs of $\sin x^\circ$ and $\cos x^\circ$ for values of x° from 0° to 360° ; alternating currents; finding an angle when a function is given; graphs of curves of trigonometric functions.

C. Logarithms

Logarithms of trigonometric functions; use of log tables in trigonometric calculations.

D. The Oblique Triangle

The law of sines, the cases, solution of the oblique triangle; the law of cosines, the cases, solution of the oblique triangle; cotangent formula for heights; applications to problems on distances, navigation, framework, surveying.

E. Areas

Triangles, two sides and included angle, one side and two angles, three sides; parallelogram, two sides and included angle.

F. Half-Angle Formulae and Tangents

Radii of inscribed and circumscribed circle, half-angle formulae, law of tangents; solution of triangles and practical problems.

3. *Business Mathematics*

Some of the practical applications of percents, income tax, profit and loss, trade discount, simple interest, instalment buying, property insurance and taxes.

4. *Statics*

A. Force, moments, centre of gravity, friction

Vectors, gravity, Newton's law of gravitation, weight; the lever, resultant of two parallel forces; calculation of centre of gravity of various solids; laws of friction, coefficients of starting and sliding friction, advantages and disadvantages; normal reaction and total reaction of surfaces.

B. Machines

Velocity ratio, and mechanical advantage, the six mechanical powers, levers of three classes, the pulley, the inclined plane, the screw, the wheel and axle, the wedge, and trains of gears.

C. Conditions of equilibrium of forces (coplanar)

Action and reaction, Newton's third law, reduction of "N" coplanar forces to a simple set, equilibrium of three coplanar forces.

5. *Specialized Mathematics*

When conditions permit their introduction, specialized courses in mathematics related to Electricity, Machine Shop, Woodworking, and Industrial Science can be stimulating to the students of these options.

6. *Theoretical Geometry* (optional)

A knowledge of geometric methods and logical reasoning as applied to this subject with some practice in the solution of deductions.

The following propositions are suggested:

Book I—Propositions 1, 2, 3, 4, 11, 16, 17, 19, and 20.

Book II—Propositions 1, 2, 3, 4, 8, and 14.

Book III—Propositions 8, 9, 11, and 15.

SCIENCE

Objectives

- (a) To arouse curiosity regarding natural objects and phenomena, in order to develop an understanding of the elementary facts of nature.
- (b) To teach pupils to observe accurately, to draw logical conclusions from their observations, and to state them clearly and concisely.
- (c) To develop the ability of the pupil to organize and correlate facts.
- (d) To interpret correctly the printed page.
- (e) To develop a better understanding of the fundamental principles of science as applied to materials, machines, and processes with which pupils come in contact.

To realize these objectives laboratory instruction should be organized to permit pupils to work individually or in small groups. The number of pupils working together will depend, to some extent, on the size of the class, on the equipment available and on the topics studied. For certain topics, where the order in which the experiments are taken is not fixed, the experiments may be carried on simultaneously.

Teachers may find it necessary to set up certain pieces of apparatus as permanent equipment to be in readiness for frequent use. Whenever possible, other equipment used should be assembled by the pupils.

Some teachers may wish to make greater use of the "unit"; or "topical", plan. Such a plan of study follows the growing interests of the pupils and, where the organization of the instruction permits, teachers should not hesitate to rearrange the content of the courses to suit this unit plan.

In employing the unit plan the teacher will organize the greater part of the course of study under a number of units, projects, or problems, which will require for their solution investigation, experimentation, close observation, and reporting by the students working in groups. Usually groups are working on different projects (or for variation of the plan, on separated aspects of the same general project) at any one time since groups will vary in their rates of working and since the amount of equipment available may be somewhat limited.

The course of study may not be fully covered merely by the completion of a required number of units. The scientific method will have been set up, however, and the interest of the students so aroused as to permit effective use by the teacher of lesson presentations of the well-known formal types, together with pupil centred discussions and reviews. Units chosen to implement this plan should take into account the age grade of the pupils, equipment available, size of class, and other pertinent factors. Units might be built around such topics as, Heating Our Homes, Water Systems for Our Homes, Rust and Corrosion.

The unit plan, of course, cannot be operated successfully without complete advance planning and preparation by the teacher. There must be available to the pupils sufficient instruction aids, and illustrative and resource materials organized in an orderly environment, to enable them to profit from this plan.

The time allotted to the study of General Science in the vocational schools may not be sufficient to complete all the topics outlined. Teachers should select from these courses the content best suited to the needs of the pupils. Approved methods of teaching should not be sacrificed to cover every detail of the course. Where classes are large, they should be divided for at least one double period per week to permit the pupils to do experimental work.

Suitable text-books, as well as books of reference, should be provided in laboratories and in classrooms where science is studied. Illustrative material, such as pamphlets, charts, process diagrams, and sample products should also be procured and filed for ready reference. Pupils should be encouraged to use these books and materials to secure additional information on the topics studied, and to understand the practical application of scientific principles and to realize their value.

NOTE:—Each school has the privilege of changing the order of presentation of the topics to suit its convenience.

GRADE IX

The course of study for Grade IX is that outlined as Part A, and two options from Part B, page 199, in Curriculum I.1., "Intermediate Division, Outlines of Courses for Experimental Use". Where a local curriculum committee has modified this course to suit the needs of the community, the modified course may be followed.

GRADE X

NOTE:—Since some of the topics of this course have been introduced in the earlier grades, some review or teaching of these topics may be necessary.

The principles involved in this course should be developed through experiments, and these, as far as possible, should be performed by the pupils. In each case, practical applications should be considered and discussed in their relation to industry, and suitable problems should be used extensively.

The teacher should observe extreme caution when dangerous chemicals and highly volatile liquids are used.

1. *Heat*

The calorie: measuring calories; heat lost or gained; the large calorie; the energy value in foods; the British Thermal Unit; the use of the B.T.U.

Specific heat; comparison of some specific heats; the use of water as related to its high specific heat.

Heat transfer: conduction; convection currents; transfer of radiant energy.

2. *Change of State*

Fusion; solidification; change of volume; latent heat of fusion; latent heat of vaporization; conversion of water to steam; expansion of water when frozen.

3. *Force, Energy and Power*

Types of force: tension; compression; shear; reacting forces; measurement of force; Hooke's law.

Pressure: Pascal's law.

Molecular force: surface tension; adhesion; cohesion; capillary action.

Force and motion: Newton's first law; Newton's third law.

Energy: potential and kinetic; conversion of chemical energy into heat; conversion of one form of energy into another.

Power: the units of work; the lever as a machine; relation between effort and load; the meaning of power; the watt; the horse power.

4. *Sound*

The origin, transmission, and speed of sound; sound waves; pitch and frequency; wave length; the relation between velocity and frequency; the difference between noise and music; sound transfer; acoustic treatment.

5. *Combustion and Slow Oxidation*

The rusting of iron filings or steel wool; slow oxidation of linseed oil; spontaneous combustion.

The composition of air; liquid air as a source of commercial oxygen, nitrogen and neon; the gases, argon, neon, krypton, xenon, radon; the commercial uses of these gases.

Oxygen: physical properties; the combustion of charcoal, sulphur, magnesium and iron in air, and in oxygen; the physical and chemical properties of the products.

Hydrogen: preparation and properties; the presence of hydrogen in fuels.

Carbon dioxide: properties and uses; properties of carbon monoxide; the production of carbon monoxide in combustion of fuels; carbon monoxide poisoning.

Combustion of candle wax, alcohol, and coal to discover the products of combustion; complete and incomplete combustion; the explosive nature of fumes and dust.

Corrosion: atmospheric oxidation of metals; methods used to combat corrosion; protection from corrosion such as surface coating, galvanizing, and plating; preparation of metals for soldering and welding; fluxes.

Optional Topics

Word equations and symbol equations for some of the changes discussed. The meaning of element and compound.

6. *Fire Fighting*

Starting fires: kindling temperature: the high and low kindling temperatures of fuels.

Putting out fires: the reduction of temperature below the kindling temperature; the need of oxygen for combustion; the use of smothering gases; methods of putting out gasoline and other liquid fires; fire extinguishers.

Methods of fireproofing paper, cloth, and wood.

7. *Solutions*

Review the use of water as a solvent.

The composition and characteristics of anti-freeze solutions, and of storage battery electrolyte; experiments, (i) to determine the density of these solutions by means of an hydrometer, and (ii) to show the capacity of an electrolyte to conduct a current of electricity; application of the information obtained from the density readings; a brief discussion of the industrial use, as solvents, of water, alcohol, acetone, and lacquer solvents.

8. *Lubrication and Lubricants*

Friction: how it is produced; the effect of friction; the need for and action of lubricants; types of lubricants; viscosity and S.A.E. ratings; the effect of temperature changes on viscosity; flash point.

The deterioration of a lubricant by dilution, dust, and sludge formation; the effect of the oil filter.

A comparison of suspensions and solutions.

9. *Metals and Alloys*

The composition, characteristics and use of cast iron, wrought iron, carbon steel, plumber's fine solder, wiping solder, brazing solder, low melting point alloys, metals for bearings, and stainless steel.

The production of a simple alloy, such as solder. Comparison of the melting point of the alloy with those of the metals used.

10. *The Composition and Classification of Foods* (optional)

Water in Foods: experiments to show that foods contain water, and how the percentage of water may be determined in such foods as fresh vegetables, fresh fruits, cereals, butter.

Carbohydrates: an experiment to detect the presence of starch in flour, potatoes, etc. An experiment to contrast sugar with starch in respect to solubility and taste. An experiment to show the presence in starch of (i) carbon, (ii) hydrogen and oxygen (as shown by the condensation of water). An experiment to show the conversion of starch to sugar (i) by the action of saliva, or (ii) by boiling with dilute hydrochloric acid. (Note change in appearance, action on hot Fehling's solution or Benedict's solution.)

Fats: experiments to show that fats (i) are insoluble in water, (ii) are soluble in carbon tetrachloride, (iii) produce a persistent greasy translucent spot on paper. An experiment to detect the presence of fat in butter, nuts, cheese, whole milk, etc.

Proteins: the composition and occurrence; experiments to show (i) that proteins are characterized by a disagreeable odour when being charred, (ii) the spot test with nitric acid and ammonium hydroxide.

Mineral Salts: an experiment to show the presence of ash or mineral matter in such foods as rolled oats and potatoes, by gently burning until combustion is complete.

The Combustion of Common Foods: a discussion of the role of carbohydrates, proteins, fats, mineral salts, and water in the diet, and the relative proportions of the food constituents listed above in such common foods as flour, rice, beans, honey, butter, lard, salad oil, peanut butter, meat, eggs, fish, cheese. Experiments to show that milk contains (i) water, (ii) sugar, (iii) fat, (iv) casein and albumen, (v) mineral matter; the value of milk as a food.

A Brief Discussion of the Carbon Cycle: recall photosynthesis, stressing the absorption of energy in a reaction which is the reverse of the oxidation of carbon-containing substances.

11. *The Human Body* (optional)

The Cell: recall the structure of a plant cell. Microscopic observation of a simple cell such as cheek epithelium to show cell wall, cytoplasm and nucleus: growth (i) by increase in size of cells, (ii) by increase in the number of cells (cell division).

The cell as an organism with the functions of nutrition, motility, and secretion. (If possible, the living amoeba or paramoecium should be examined by the pupils.)

The meaning of tissues, organs, systems.

Digestion and Absorption.

NOTE:—If section 10 has been studied, the following experiments on carbohydrates, fats, and proteins should be omitted.

Carbohydrates: an experiment to show the presence in starch of (i) carbon, (ii) hydrogen and oxygen (as shown by the condensation of water.)

An experiment to show the conversion of starch to sugar by the action of saliva.

Fats: the composition of fats; experiments to show that fats (i) are insoluble in water, (ii) are soluble in carbon tetrachloride, (iii) produce a persistent greasy translucent spot on paper.

Proteins: the composition and occurrence of proteins; experiments to show (i) that proteins are characterized by a disagreeable odour on charring, (ii) the spot test with nitric acid and ammonium hydroxide. The meaning of digestion; the alimentary canal; a brief discussion of digestive changes taking place in each of the parts; glands and juices taking part in these changes.

Absorption of digested food.

Circulation, Respiration and Excretion.

The blood and the lymph: observation of the circulation of blood in the web of a frog's foot or in a tadpole's tail; microscopic examination of a drop of blood diluted with physiological saline solution (0.9% common salt).

The constituents of the blood and their functions.

The circulation of the blood in the human body (names of arteries and veins not required); the changes taking place in the tissues, the kidneys, and the lungs.

Protection from disease by the formation of anti-bodies.

An experiment to show that exhaled air contains more carbon dioxide than air in a room; the meaning of respiration (energy transformations). The organs of breathing; the great surface area in the lungs; how breathing is carried on.

12. *Elementary Mineralogy* (optional)

Physical Mineralogy.

Physical properties of minerals (omit hardness).

Scale of hardness as used in the identification of minerals.

Identification of quartz—massive, jasper, flint; identification of feldspars; comparison of orthoclase and plagioclase feldspars.

Native minerals—identification of gold, silver, copper, sulphur, graphite, coal.

Sulphides and arsenides—identification of iron pyrites, copper pyrites, galena, molybdenite, smaltite, zincblende.

Chlorides, fluorides, and carbonates—identification of halite, fluorite, calcite, dolomite, magnesite, malachite, azurite.

Silicates—identification of hornblends, augite, garnet, olivene, epidote, tourmaline, mica, chlorite, serpentine, kaolin.

Phosphates and sulphates—apatite, barite, celestite, gypsum, wolframite, scheelite.

Rocks:

Common rock-forming minerals.

Definition of a rock; classification of rocks.

Igneous rocks—formation; identification of granite, syenite, diorite, gabbro, diabase basalt, fine-grained, even-textured rocks such as felsite and basalt, very fine-grained glassy rocks such as porphyry.

Sedimentary rocks—formation; identification of conglomerate, breccia, sandstone, shale.

Metamorphic rocks—formation; identification of gneiss, schist, quartzite, slate.

Chemical Mineralogy:

The use of the blow-pipe; reduction and oxidation of litharge in the blow-pipe flame.

Identification of arsenic, antimony, bismuth, copper, iron, lead, silver, and sulphur, by means of chemical tests.

13. *Biology* (optional)

A brief treatment of the general structure and function of plants and animals, a microscopic examination of leaf structure, photosynthesis, fungi and yeasts, bacteria and fermentation. See Curriculum I.1, Grade X.

GRADES XI AND XII

These Courses of Study are based upon the scientific requirements of the Shop Work Courses for Vocational Schools.

While every effort should be made to have the pupils follow an experimental course, or treat the topics as pupil-research topics, the presentation of many of the topics requires discussion by the class. The pupil should be encouraged, therefore, to acquire knowledge and understanding through his own individual efforts, and to make use of suitable reference and illustrative materials, which should be available in a properly indexed form.

Each school may decide whether Physics and Chemistry is to be studied concurrently or consecutively. If the latter plan is chosen, the Chemistry should be taken in Grade XII.

The core topics are listed, and those parts indicated with an asterisk are suggested as enrichment topics, to be used as circumstances warrant. If time permits, it may be desirable to include topics which apply to local industries. In the Chemistry course, some teachers may wish to stress such topics as agricultural chemistry, metals, polymers, and plastics.

NOTE:—These topics need not be taken in the same order as listed here.

PHYSICS

1. *Accurate Measurements*

Review of units of linear measure (English and Metric); practice in the use of the steel rule and calipers; construction and use of vernier calipers and micrometer; problems involving volume of regular solids using vernier calipers, tolerances, significant figures; measurement of masses of the foregoing solids and determination of buoyancy.

Fine measurement of volumes and masses may be best combined with experimental work on density and specific gravity. See topic 2.

2. *Mechanics of Fluids*

Experiments to determine the density of liquids by using the specific gravity bottle and the hydrometer; the specific gravity of heavy solids; solids lighter than water; fluids by means of the hydrometer. A discussion of the various scales in use.

Problems on density and specific gravity.

3. *Machines*

Review of Grade X work. An experimental study of the three classes of levers to determine the mechanical advantage of each. The classification and use of such levers as are found in the shops.

A study of the class, mechanical advantage and application of the pulley, toothed gear, wheel and axle, inclined plane. Study and classification of the wedge, the screw, the differential pulley and complex machine parts.

A study of the mechanical advantage and efficiency of some simple machines which use these principles.

Rules for calculations and problems.

4. *Force*

Review the meaning and kinds of force.

The units for measuring force: pound, gram; the meaning of H.P.; a demonstration of B.H.P.

Experiments to determine: the equilibrant and resultant of parallel forces; equilibrant and resultant of two forces acting at an angle; verification of the law of the parallelogram of forces.

A discussion of the moment of force; the application of the moments of force to the lever and the wheel and axle.

Study of: friction, coefficient of; laws of motion—helicopters, jets; projectiles; Bernoulli's principle—speed indicators, pitot tube.

Mechanics of motion: impulse and momentum; acceleration due to gravity and in machines "g" factor.

5. *Electricity*

Review current electricity, and the meaning of work, energy and power with emphasis on gravitational potential energy.

A study of electromotive force and factors controlling electric current flow; magnetic effects of electric current; applications of electromagnetism; D'Arsonval galvanometer; the ammeter and voltmeter.

An experiment to determine the resistance of a conductor using the voltmeter-ammeter method. Simple problems involving Ohm's law.

Experiments to show induced currents—principle of the induction coil.

Simple experiments to illustrate the fundamental principles of the AC and DC transformer, motor and generator (structural details are not required).

Heating and lighting effects of an electric current, fuses, and circuit breakers.

Industrial uses of electric current: (1) welding, (2) electric furnace, (3) electric lamps (incandescent, mercury vapour, sodium vapour, neon, fluorescent).

Thermocouple to measure temperature, (AC and DC currents); induction; transformer; radio-tube electronics; transistors; photo-electric cells.

6. *Light Energy*

A discussion of light as radiant energy—two concepts.

Experiments to show: the composite nature of white light; the colours of the solar spectrum; reflection from plane surfaces; images in plane mirrors, and curved mirrors; refraction of light; the uses of lenses.

Applications of curved mirrors—headlight, rear vision; lenses—eye, camera, movies, stereo pictures, projection.

The physical nature of colour; Newton's experiment; the colour of objects in white light.

The structure of the human eye, and methods of correcting defects with glasses.

Colour blindness; colour mixing; Kodachrome; 3D colour process; 3D movies.

7. *Lighting for Vision*

A study of the accepted standards of illumination used in modern lighting for home, school, factory, display, flood lighting; the law of inverse squares; the incandescent lamp measurements; the principle involved in and use of a light meter.

The meaning of plane-polarized light. Simple experiments to show the nature and effects of polarized light, using a pair of polarized disks; the application of polaroid to automobile driving as glare prevention with sun glasses.

8. *Heat*

Review or study of heat units, and heat capacity. An experimental study of: specific heat of water; specific heat of metals; heat of fusion of ice; heat of vaporization of water; heat of vaporization of other liquids; the effect of increased and decreased pressure on the boiling point of liquids.

Application of the above principles as in heating and refrigeration.

Review of hygrometry. The principle of air conditioning, particularly in respect of moisture content.

GRADES XI AND XII

CHEMISTRY

1. *The Meaning and Purpose of Chemistry as Compared with Physics*

Review of the states of matter. The use of the physical properties of a pure substance in its identification.

2. *Chemical Change*

Experiments to show chemical change in contrast with physical change and methods for distinguishing between them. Heating mercuric oxide; electrolysis of water; light on silver halide, catalytic action of manganese dioxide. How new substances are formed, energy change.

3. *Mixtures*

The meaning of mixtures, and the difference between a mixture and a pure substance.

Experiments on separating mixtures: magnetic; filtering; settling; starch filtering; flotation; solvent extraction; distillation; freezing; crystallization.

A study of the application of these types of separation in industry.

4. *Elements and Compounds*

An experiment on the decomposition of a compound.

A comparison of mixtures and compounds.

The meaning of an element and a compound: definition; method of naming; the structure of the atom; simple chemical reactions; reacting weights and atomic weights; symbols, formulae, equations, valency.

The gas laws; measurement of gases; changing the volume, pressure or temperature of a gas. Problems on the application of the gas laws.

The molecule and determination of molecular weights.

5. *Oxygen*

Review of the composition of air.

An experiment to prepare oxygen and to determine its properties; test for oxygen; the uses of oxygen; oxy-acetylene welding; oxygen masks; oxygen tents.

6. *Hydrogen*

Experiments to prepare hydrogen from water and from acids. The properties of and test for hydrogen. Uses of hydrogen: oxy-hydrogen torch; weather balloons; constituent of gaseous fuels; hydrogenation of fuels.

7. *Solutions*

Comparison of characteristics of solutions with those of mechanical mixtures.

Examples of solutions. These should be varied enough to show the existence of solutions in different physical states: e.g. air, including water vapour; low-melting alloys; gold and copper alloys; oil or grease in carbon tetrachloride; DDT in kerosene; carbonated beverages.

Meaning of terms: solvent, solute, solubility (relative and quantitative); saturated, unsaturated, and super-saturated solutions; solubility curve (to illustrate change of solubility with temperature). Factors which affect the rate of solution.

8. *Acids, Bases, and Salts*

Experiments to show the combustion in oxygen of carbon, sulphur, and red phosphorus; the reaction of these oxides with water, and the effect of their solutions on litmus.

Acidic oxides—acid anhydrides: hydrochloric, nitric and sulphuric acids.

An experiment to show the combustion of magnesium in oxygen.

A demonstration of the combustion of sodium in oxygen.

The reaction of these metallic oxides with water, and the effect of their solutions on litmus. Basic oxides—basic anhydrides.

Discovery of further properties of acids (dilute) using (1) other indicators, (2) action on carbonates, (3) action on suitable metals (magnesium), (4) taste as shown by soda water, vinegar, sour milk, etc.

Discovery of the effect of bases on the indicators used for acids.

Experiments to show the reaction between acids and bases; the products of the reaction (neutralization), water, and a salt which is left as a residue upon evaporation of the water.

A brief discussion of the commercial recovery and industrial importance of common salt (sodium chloride); a study of its properties; a study of the reaction of sulphuric acid with salt; the laboratory preparation and properties of hydrogen chloride and of hydrochloric acid.

9. *The Theory of the Ionization of Acids, Bases, and Salts*

A demonstration of the electrolysis of cupric chloride solution, with an explanation in terms of charged particles.

A discussion of the dissociation of cupric bromide, hydrogen chloride, when dissolved in water giving rise to electrically charged particles, called ions.

A discussion of the hydrogen ion as the characteristic ion of acids; of the properties of acids (taste, effect on litmus and other indicators, action on metals, etc.) as being due to hydrogen ions in the solutions.

A discussion of the dissociation of sodium hydroxide in solution.

A discussion of the hydroxyl ion as the characteristic ion of bases; the properties of bases (taste, effect on litmus and other indicators, caustic action on animal and vegetable matter, e.g., textiles (mercerization of cotton), as being due to hydroxyl ions in the solutions.

A discussion of neutralization as a quantitative reaction depending upon the removal of hydrogen ions and hydroxyl ions to form water.

A brief discussion of the measurement of acidity in terms of hydrogen ion concentration.

How an atom becomes an ion.

The meaning and measurement of pH—the effect of pH on life and growth.

10. *The Lead Storage Cell*

An experiment to show: electroplating with copper sulphate solution; the preparation of the electrolyte.

Review of the use of the hydrometer and discussion of the use of the density-concentration tables.

An experiment to “form” a storage cell, using lead plates, with a reference to the composition of the plates before and after forming. “Discharging” the cell and the alteration of potential as shown by the voltmeter; degree of discharge.

A discussion of the charging of the cell with special reference to the transformation of electrical energy to chemical potential energy; and the discharging of the cell in terms of the reverse transformation of energy.

The efficiency of the commercial storage battery; a comparison of the output of electrical energy with the input of electrical energy; reference to the dissipation of some energy in heating the cell and decomposing the electrolyte.

11. *Miscellaneous Topics*

Titration in control laboratories and ionization. Equilibrium and mass action—reversible and complete hydrolysis, illustrated by copper bromide.

An experiment to show commercial electroplating.

The electrolysis of a sodium chloride solution and the recognition of the products.

Refining of copper, silver and gold; production of chlorates and hydrogen peroxide.

Electric furnaces for graphite, silicon, carborundum, carbide, alundum, phosphorus, carbon disulphide.

12. *Combustion and Fuels*

Experiments to show that certain mixtures of gasoline or acetylene and air give complete combustion, and that others give incomplete combustion.

A discussion of complete and incomplete combustion of hydrocarbons.

Review the formation of carbon monoxide in the automobile engine, and during the combustion of coal or coke.

Experiments to illustrate the complete and incomplete combustion of acetylene.

The use of the oxy-acetylene flame for welding, with special reference to the correct mixture of oxygen and acetylene.

Repeat the experiment to show the burning of iron in oxygen.

The use of the oxy-acetylene flame for cutting, with special reference to the correct mixture of oxygen and acetylene.

An examination of the structure of the Bunsen burner and its flame.

A discussion of the complete and incomplete combustion of natural gas or coal gas.

A review of explosive mixtures with special reference to the “striking-back” of the flame of the Bunsen burner.

A study of the oxidizing and the reducing zones of the gas flame.

A discussion of the world locations of petroleum oil, and the methods and channels of distribution, with specific reference to the requirements of the British Empire.

Experiments to illustrate (1) the distillation of water, and (2) the fractional distillation of a water-alcohol solution.

A discussion of the principles of fractional distillation and cracking in petroleum refining.

A brief discussion of types and grades of motor fuels; octane numbers.

A recall of lubrication and lubricants, Grade X.

An examination of other petroleum products, with a brief outline of their uses.

A brief discussion of other fuels such as coal, industrial gases.

13. *Metallurgy*

A discussion of the kinds and sources of iron ores, such as sulphides, oxides, carbonates. Separation from the rock, concentration and extraction. Flotation, roasting, and reduction.

The construction of the iron blast furnace, and reference to the heat exchange in a stove.

A demonstration of carbon monoxide as a reducing agent. Recall the dangerous properties of carbon monoxide.

An examination of the constituents of the blast furnace charge, and the purpose of each substance, in the operation of the blast furnace.

The construction and use of the iron cupola.

The composition and characteristics of cast iron, carbon steel and wrought iron.

A brief study of the manufacture of steel by (1) the acid Bessemer process, (2) the basic open-hearth process.

The heat treatment of steel; methods and purpose of annealing, hardening, tempering; surface hardening by (1) case hardening, (2) nitriding. This should be coordinated with projects in heat treatment in the machine shop.

The composition and characteristics of types of steel: tool, nickel, tungsten, manganese, stainless, silicon.

14. *Alloy Steels and Alloying Metals*

The meaning and purpose of alloys.

Review of properties of metals and chemical reactions serving as tests.

Some common alloys and their industrial applications.

The replacement series of metals.

A discussion on corrosion and its prevention.

15. *Limestone*

The composition, properties and uses of limestone.

An experimental study of the preparation and properties of quicklime; the kinds of quicklime.

An experimental study of the preparation and properties of slaked (hydrated) lime; the action of carbon dioxide on slaked lime.

An experiment to show the preparation of lime-sand mortar, its initial set, and final hardening. Other uses of slaked lime.

16. *Gypsum*

The composition, properties and uses of gypsum.

Experiments to show:

- (a) the action of heat on a hydrate such as blue vitriol, and the action of water on the anhydrous residue.
- (b) the conversion of gypsum into plaster of paris.
- (c) the effect of the addition of water to plaster of paris.

A discussion of other gypsum products such as wallboard, gypsum blocks, and acoustic materials.

17. *Cement and Concrete*

A study of the composition, properties and manufacture of cement.

An experiment to study the initial set and final hardening of cement.

A study of the composition and function of the components of concrete, effect of impurities, moisture, temperature, mixing, and the strength of the mix.

A comparison of the setting of concrete with that of lime-sand mortar.

How to determine quantities for concrete. The uses of concrete.

Recall the expansion of water on freezing, and its application to the disintegration of concrete.

Recall the action of carbonic acid on limestone, and discuss the similar disintegrating action on the calcium salts in concrete.

18. *Wood*

A brief discussion of the chemical composition of wood.

Experiments to show:

- (a) the effect of heat on wood at various temperatures; the meaning of kindling temperature; wood as a fire hazard.
- (b) the protection of wood against fire by covering the wood with fire proof coatings as sodium silicate. Other protective coatings: plaster, asbestos, fire resistant paints, impregnation of the wood with chemicals such as ammonium phosphate, ammonium sulphate, or borax. The function of these non-combustible chemicals in diluting the combustible gases given off by the hot wood.
- (c) the open-tank process and the Kyanizing process for the preservative treatment of wood; methods employed for impregnating wood with preservatives.

Brief discussion on:

- (a) fungus decay of wood and the conditions necessary for the development of fungi in wood.
- (b) kiln drying for the preservation and seasoning of wood.
- (c) the application of paint, varnish and lacquer to the preservation of wood; an experiment to compare the effect of air on a thin film of linseed oil and of mineral oil.

19. *Metals*

A brief study of the properties and industrial application of metals such as aluminum, magnesium, lead, tin, zinc, copper, nickel, beryllium, cadmium.

20. *Organic Chemistry*

A brief study of straight-chain and ring-structure, alcohols, acids, esters, acetone, glycol, solvents, formaldehyde, ether.

21. *The Halogens*

A brief study of the halogens to show that all chemical elements can be arranged in family groups, the members of which are closely related. This can be combined with a study of the Periodic Table.

22. *For Students of Electronics*

A discussion on radio-active metals and materials leading up to nuclear fission.

MAJOR SHOP WORK COURSES

Suggestions for the use of the Shop Work Courses

The outlines for the shop work courses in vocational schools as provided herein are not necessarily arranged in order of presentation. They are designed for the maximum shop work time as set forth in the introductory statement in this pamphlet, and on the assumption that five shop subjects will be offered in Grade IX. In schools where a larger or smaller number of shop subjects is offered the courses should be modified to suit the time available. In schools where it may be desirable to teach courses not specified in these outlines a synopsis of such courses of study should be submitted for the approval of the Minister before they are adopted. In organizing time-tables, the semester plan or the rotary plan is suggested in order to reduce the number of subjects carried concurrently by pupils.

The project is the usual basis for the presentation of shop instruction. Projects to cover the topics of the course should be selected with a view to the interests and abilities of the pupils and should offer sufficient variety. The well-directed use by the pupils of carefully planned shop-libraries, illustrative materials, and other instructional aids will promote the close co-ordination of intelligent study with the development of recognized standards of performance in trade operations.

In planning and presenting instruction, teachers are asked to take into account previous training and experience which pupils have had, whether in school or elsewhere.

The variety and quantity of the equipment available will determine the selection and arrangement of the topics from the following courses of study. From these courses the teacher should make a detailed organization of the work for each class. Frequent and systematic appraisal of the pupil's work should be made, giving credit for achievement in practical work, tests and examinations, home-work, note-book records, and, if desired, general adaptability to the instruction.

Pupils majoring in a shop subject must take related shop subjects. To conserve shop time for shop work the science, mathematics and drafting related to the various shop courses should be taken in the respective departments.

Unless provided for under the vocational guidance organization of the school, definite information with respect to the opportunities in the various related occupations and the particular job requirements should be made available to the pupils in order to assist them in making a wise choice of their future vocations.

Dangerous conditions affecting the health and safety of pupils in school must be avoided. Exhaust gases from running engines and fumes from spray guns and heat-treating processes must be effectively discharged. All machines must be properly guarded; safety instruction must be given in every shop where hazards exist; and a first-aid cabinet must be readily accessible. A clean and well-appointed shop, with equipment maintained in first-class operating condition is an important factor in the prevention of accidents.

GRADE XI

Pupils enrolled in Grade XI are required to elect a major shop in which to specialize. Instruction in this elected shop is to be supplemented by instruction in a number of related shops. In the case of most major shops, drafting should

be a related shop. Typewriting may be offered in lieu of one related shop, and this subject should be given in single periods. The time devoted to shop work may be distributed among the major and related shops according to the varying demands of industry for highly specialized workmen and the capacity of the school organization to meet the needs of the particular enrolment.

GRADE XII

Pupils enrolled in Grade XII are expected to continue their courses on the specialized plan as set up for Grade XI. A course of simplified bookkeeping and record keeping may be offered in lieu of a related shop. This subject should be given in single periods, and in a typing room so that the pupils can improve the typing skill acquired in the Grade XI course.

AIRCRAFT

GRADE X

AIRFRAMES

Parts and Materials

- (a) Names, function, and location, of the main parts of fuselage, wing and tail assemblies.
- (b) Purpose of and materials used in, turnbuckles, clevis pins, wing ribs, spars, longerons and struts.
- (c) Aircraft woods and plywood, glues, wood protectives, cables, airplane dope and its function, specification of fabrics, fabric stitching, fabric surface tape, and reinforcing tape, types of seams, use of grommets and zippers, classification of metals, and heat treatment.

Operations

Locking of airframe parts, wrapping splices, tying rope knots, removing and assembling wheel units; removing, repairing, and replacing inner tubes; covering a small frame with fabric, applying dope with a brush, rubbing down the doped surface to finish, and installing a light plane undercarriage.

General

A study of the stresses to which airplane parts are subjected; fire hazards and safety precautions; care and sharpening of tools.

AERO ENGINES

This study should be confined to a four-cylinder opposed-type engine.

Parts

Investigation to obtain knowledge of location, function, and materials used in the following.

Overhead and side valve mechanisms, pistons, piston rings, cylinder and cylinder head assemblies, connecting rods, crankshafts; plain, roller and ball bearings.

Cooling System

- (a) Advantages of air-cooled engines.
- (b) The function of radiators, pumps, and thermostats.

Fuel System

- (a) Tracing a simple fuel system which includes: tank, pump, filter, selector valve, and carburetor.
- (b) Carburetion: the purpose and identification of the main carburetor parts.

Lubrication System

Examination and charting of the lubrication system used in the four-cylinder, opposed-type engine being studied.

General

- (a) Review of the two and the four stroke cycle of operation.
- (b) Removal and replacement of cylinder and piston assemblies, piston rings, valves, and studs.
- (c) Grinding valves by hand; adjusting valve clearances; locking, using cotter pins and locking wire; cutting gaskets; servicing a spark plug.
- (d) Classification of internal combustion engines.
- (e) Starting and running adjustments for an outboard motor.

METAL WORK

The following is in addition to the regular grade IX Industrial Metal Work.

General

Identification of aluminum and its alloys; selection of drill sizes for a variety of rivets; fraction, and number drills; types of rivets and the rivet code; selection of proper rivet sets; rivet spacing.

Operations

Accuracy stressed in layout work, additional practice in the use of portable, and bench drills; burring drilled holes; use of metal holders; hand-riveting using bucking bars; making a rivet gauge.

AIRCRAFT IGNITION

An experimental study of the fundamentals of electricity: types of circuits, conductors, resistors and insulators; meaning of voltage, amperage and resistance; Ohm's law; use of voltmeter and ammeter; study by experiment of voltage, amperage and resistance of series and parallel circuits; experimental study of magnetism, electro-magnetic field about a current-carrying conductor, and helix.

A study of the solenoid-operated, starting motor: dismantling; identification of parts and material by name; purpose and operation of solenoid and motor; assembling and operating starter-motor; a layout of the starter-motor circuit.

GRADE XI

AIRFRAMES

Parts and Materials

A detailed study of the construction features and the materials used in: wings, wing spars, wing ribs, fuselages, and landing gears.

Operations

Tuck splicing; scarfe splicing; rope splicing; assembling and alignment of wheel, float, and ski undercarriages; flying control inspection and adjustment; preparation of a structure for fabric covering, repair of fabric; shock cord whipping; layout and construction of a rib jig, building a trussed wing rib; metal protection; dismantling and assembling a complete tail unit; checking of tail-plane rigging.

General

Flying faults and their correction; fire-fighting equipment and its use; operation of a dope room; use of thinners, reducer, and rejuvenator.

AERO ENGINES

A radial engine of medium horsepower is suggested for study.

Parts

A detailed study of crankshaft and connecting rod construction: use of step studs.

Fuel System

- (a) Comparison of gravity and pressure-type fuel systems.
- (b) Construction of fuel gauges, filter units, and primers.
- (c) Construction and overhaul of fuel pumps.

Lubrication System

- (a) A thorough study of the radial engine dry-sump lubrication system.
- (b) Construction and function of gear-type oil pumps; relief valves; oil tanks.
- (c) Seasonal oil changes, oil dilution, its purpose and application.

Jet Engines

- (a) Theory of jet propulsion. Identification of the main jet engine parts.
- (b) Comparison of the axial flow and the centrifugal flow jet engines.
- (c) Assessing the merits of piston and jet engines.

General

- (a) Decarbonizing and cleaning of valves, valve guides, cylinder heads, pistons.
- (b) Practice in the use of reamers and hones. Removal of scratches; the treatment of scores; valve reseating and valve refacing.
- (c) Measuring cylinders for out-of-round and taper; fitting piston rings.
- (d) Firing order of cylinders and the history and development of valves.
- (e) Engine starting and carburetor adjustment; checking engines using a vacuum gauge, compression gauge, and exhaust gas analyzer.

AIRCRAFT THEORY

General

A study of aircraft terminology under the following headings: types of aircraft, parts and related terms, general terms, and flying terminology.

Airfoils

A study of the motion of air past a flat surface at various angles of attack; a practical demonstration of the development of a lifting surface with the Venturi tube; streamline flow; turbulent flow; effect of velocity and area on lift; aspect ratio and lift; biplane interference; airflow about various shapes.

Problems

Calculation of air speed and ground speed, wing loading, power loading; plotting a simple course.

Air Regulations

Scope of the Aeronautics Act, rules for air traffic, aircraft markings and lights, breach of air regulations; aircraft, engine, and propeller log books; composition of personnel.

Engineering Handbook of the Department of Transport

A selection of items covered to familiarize students with the scope of this manual and a discussion of the origin of and need for several of the directives.

General

A brief introduction to the following: the axes, stability, controls, balanced controls, Frise ailerons, differential ailerons, slots, flaps, adjustable stabilizers, tabs, propellers.

AIRCRAFT INSTRUMENTS

General

The contribution of instruments to the flight of the modern airplane.

Engine Instruments

A study of the construction, operation, and testing of Bourdon tube instruments and manifold pressure gauges.

Flight Instruments

A study of the construction, operation, and testing of each of the following instruments:

Air speed, rate of climb, altimeter, suction, directional, gyro, artificial horizon, turn and bank, compasses.

Deviation, variation, swinging a compass.

Metal Work

A more detailed study of aluminum and its alloys; identification markings for steel and its alloys; care of templates, head markings and colour code for rivet identification, storing and handling rivets, use of blind rivets; buffing wheels, compounds, abrasives, burnishing and surface conditioning methods used in metal finishing; protection against corrosion.

Operations

Laying out from blueprints and working from templates; operating and caring for pneumatic drills, rivet hammers, rivet squeezers, and Cherry rivet guns; using bending blocks, bumping forms dies, and sand bags; countersinking and dimpling; determining bend allowances; stretching, and shrinking metal using hand tools; removing defective rivets.

IGNITION

Aircraft Electrical Units

A practical and theoretical study of the electrical circuits and units of the aircraft.

Generator

Dismantle, identify parts and materials; differences in purpose and construction of generator and motor; purpose and operation of generator; assemble and operate generator; generator charging circuit.

Cut-out, Current, and Voltage Controls

A study of the construction and operation of the controls, using factory manuals and units. Practical experience adjusting and setting regulators.

Ignition Circuit

Construction and operation of high tension coils, condenser, distributor and complete ignition circuit, using manuals, and live engines.

GRADE XII

AIRFRAMES

Overhaul and Testing

- (a) A study of the following hydraulic units: flap and undercarriage jacks; relief and selector valves; engine driven, and hand pumps; oleo legs; accumulators, pressure-control valves, wheel, and master-brake cylinders;
- (b) constant speed propeller controls; controllable pitch propellers; hydraulic brake units; and multi-disc brake assemblies.

Servicing and Adjusting

- (a) A study of hydraulic, and mechanical brakes; retractable undercarriages; controllable pitch propellers; trimming, and balance tabs; flaps,
- (b) An airplane in rigging position to check fuselage alignments, tailplane alignment, dihedral and angle of incidence of the wings; inspection after a hard landing.

General

Paint spraying equipment, its use and maintenance; principles of hydraulics; airplane slinging precautions; dismantling and assembling wings; repairing of steel tubing; layout and fabrication of various wing and fuselage steel fittings; protection of metals.

AERO ENGINES

Radial, jet, and V-type engines to be used.

Parts

Investigation to obtain detailed knowledge of construction and materials used in the following assemblies:

- (a) radial-engine valve-drive mechanisms; supercharger impellers, diffusers; drive assemblies.
- (b) jet-engine impellers; diffusers; combustion chambers; turbine mechanisms.

Fuel System and Carburetion

- (a) A detailed study of carburetion requirements at altitude and throughout the speed range.
- (b) An intensive study of the construction and operation of the following: float chamber mechanisms; main jets; idling, altitude, economizer, and accelerating systems.
- (c) A study of ice formation and heat application; the design requirements of intake systems, octane rating, and detonation.
- (d) An investigation of fuel injection, and fuel injection carburetors.
- (e) The operation of single, and two-stage superchargers; inter-cooling; and turbo-superchargers.

Lubrication

- (a) The history, and development of oils, fuels, and greases.
- (b) The preparation of the lubrication system for cold-weather operation.

Major Overhaul

- (a) The complete dismantling of a radial engine.
- (b) The inspection of crankshaft and connecting rods using dial test gauges, alignment jigs, and magnaflux equipment.
- (c) The assembling and checking of parts for fits and clearances.
- (d) Valve and ignition timing.

General

A study of starting and running adjustments, and detailed trouble shooting.

Jet Engines

- (a) The complete dismantling of a jet engine.
- (b) Inspection to determine materials used in the various units and the serviceability of parts.
- (c) The tracing of the lubrication system.
- (d) The checking of clearances, and the assembling of the engines.
- (e) A study of fuel requirements, and fuel control; starting, and running adjustments.

AIRCRAFT THEORY AND AERODYNAMICS

The course of grade IX reviewed and extended in each of the topics listed.

- (a) A study of LIFT AND DRAG: the resultant, lift and drag components; induced, parasite, profile, and interference drag.
- (b) STABILITY: longitudinal, lateral, and directional stability.
- (c) CONTROL SURFACES: flying controls; slots; flaps; adjustable stabilizers; trimming tabs; Frise ailerons; differential ailerons.
- (d) PROPELLERS: terminology; fixed pitch; adjustable pitch; controllable, and constant speed; the advantages of each.
- (e) TEST EQUIPMENT: wind tunnels; smoke tunnels; water channels; balances.
- (f) SURFACES: flat and curved surfaces; various shaped models in an air-stream; derivation of streamlined sections; lift, drag, longitudinal, lateral and directional stability.
- (g) HIGH SPEED FLIGHT: flight, and the speed of sound; shock waves; temperature, and the speed of sound; Mach number; sonic barrier; airfoils, and supersonic flight.

METAL WORK

General

Identification of stressed and non-stressed skin; protective coatings, such as anodizing, paint and lacquers, zinc chromate.

Operations

The use of the following tools and equipment: metal band saw, electric nibbler, electric shears, hole saws, form blocks, cutting dies, hand and power press, rubber mats in press forming; drilling to templates, fabricating in jigs; flanging; hardening, tempering, and annealing; hardness testing, lap and flush patching, float patching and water proofing; repair and replacement of stringers, and channel webs.

WELDING

General

A study of the gases used; safety measures; construction and care of welding apparatus; flame characteristics; selection of proper welding rod; fluxes used for welding cast iron, and bronze; construction and operation of cutting torch.

Operations

The preparation of steel for a variety of joints; practice in welding butt, and lap joints; fillet welding; manipulation of blow pipe and rod; forward and backward ripple welds on steel; simple tests for fusion penetration and bead; welding cast iron; welding a cluster tube joint. Practice in the free-hand use of cutting torch to layout.

IGNITION

Study of Magnetos—three types

Rotating armature, rotating magnet and polar inductor. Dismantling, identifying parts; a study of the purpose, construction, operation, assembly, operation and timing of each type to engine.

Lighting circuits and relays

A study of types of circuits used; location of wiring and units; precautions in wiring aircraft: purpose, location, and operation of relays: application of motor-generator units to generate AC current of various cycles for instrument operation.

Storage Batteries

The construction, operation, location, purpose and maintenance of 6, 12 and 24-volt storage batteries.

APPLIED ELECTRICITY

GRADE IX

1. *Circuits*

Simple circuits developed, stressing the effects of series and parallel loads by observation using lamps or bells and buzzers. Standard symbols to be used for lighting circuit diagrams.

Construction and general use of lamp and appliance cords (2-3 wire.) Replacing a switch and convenience receptacle.

Electrical hazards, and precautions to be taken, in the home.

2. *Joints, Soldering, Weatherproofing* (introduced as required)

(a) Making simple joints such as rat-tail, tee, and western union.

(b) Soldering, preparation of soldering iron and use of flux in soldering joints.

(c) Weatherproofing: taping and the use of compound.

3. *Magnetism and Electro-magnetism*

Magnetic field about permanent magnets examined by use of iron filings or small compasses: study of polarity, making an electro-magnet; study of the magnetic field and polarity; examination of the field of force about a single wire carrying a current of electricity; development of "right hand rule".

4. Study of action of electric bells, buzzers, and annunciators.

5. *Conductors and insulators*

Experimental study of a few common metals and non-metals as a basis for classification into conductors and insulators.

6. *Circuit protection*

Heating effect of electric current; construction, purpose and rating of simple fuses (plug and cartridge type); an experiment to show the protective value of the fuse, with application to the circuits in the home.

7. *Electrical units*

An experimental knowledge of the three basic electrical terms, as applied to parts 1-6 above, to convey the general idea of electrical pressure, resistance and current, in relation to Ohm's law.

GRADE X

A. INSTALLATION AND MAINTENANCE

The course should be closely connected with, and the workmanship should conform to, the requirements of the Hydro-Electric Power Commission of Ontario.

1. *Splices and Joints*

Proper construction and use of joints and splices as used in lighting and power circuits. The use of solderless connectors.

2. *Materials*

Study of the B. and S. gauge wire tables; recognition of commonly used wires and cables according to size, insulation, and use; identification by name, size, and description of other trade materials within the scope of this course.

3. *Circuits*

Domestic light and power circuits: construction (knob and tube) of the elements of lighting circuits such as might be suitable for a seven-roomed house; construction in non-metallic sheathed wire and cable.

4. *Elementary testing and repair of simple domestic electrical appliances*

The testing referred to in this course is to be confined to the use of a test lamp and bellringer. Electrical hazards to be stressed.

B. THEORY AND TEST

1. *Electro-magnetism*

Plotting fields of force about conductors carrying current to develop the right hand rule and helix rule; the effect of increasing (1) turns, (2) current, through a coil of wire having an iron core; electro-magnetism as applied in electric bells, relays, circuit breakers, and lifting magnets.

2. *Conductors and Non-conductors*

A more advanced study and experimental determination of the ability of common metals, non-metals, and solutions to conduct current.

3. *Heating effect of electric current*

Circuit protective devices (fuses and thermal cut-outs).

4. *Instruments*

Ammeter and voltmeter; location in the circuit and precautions for proper use.

5. *Ohm's Law* (experimental study)

(a) Effect on current in circuit produced by varying the resistance and holding the voltage constant.

(b) Effect on current in circuit produced by varying the voltage and holding the resistance constant.

(c) Development of equations.

6. *Resistors, Resistance Measurement, Circular Mil Measure*

(a) An examination and study of common resistance materials found in household appliances, such as lamps, motors, motor-starters, and heaters.

(b) Comparison of wire diameters with standard tables; comparison of mil-foot resistances of wires in common use.

7. *Circuits*

Determination of current, voltage, and resistance characteristics of typical series and parallel circuits.

8. *Voltage Drop*

Measurement of voltage drop in simple electric circuits for light, heat and power.

9. *Measurement of Power*

Three methods: volt-ammeter, wattmeter (kilowatt-meter), and watt-hour (kilowatt-hour) meter; horse power in terms of kilowatts.

GRADE XI

(See also Related Courses: **DRAFTING** for Applied Electricity, p. 90; **MACHINE SHOP PRACTICE** for Applied Electricity, p. 95; **WELDING** for Applied Electricity, p. 99.)

A. INSTALLATION AND MAINTENANCE

1. *Circuits*

(a) The installation and study of more advanced work in electric services; non-metallic, metallic, and rigid conduit circuits for domestic light, heat, and power,

(b) Installation of fractional motors using different types of starters and protective devices commonly used in industry.

2. *Testing and Repair*

- (a) Testing and repair of circuits used in light, heat, and power, including D.C. motors, generators, and industrial control equipment,
- (b) Stripping, securing, winding data; rewinding one D.C. armature; making all necessary tests before, during, and after rewinding; truing-up commutator, undercutting mica, and complete final check-up before assembling for running test.

B. THEORY AND TEST

1. *Electro-magnetism*

- (a) Application of Ohm's Law to the magnetic circuit to determine the relations between magneto-motive force, flux density, and reluctance,
- (b) Development of magnetic circuit equations and plotting of magnetizing curves for cast iron, wrought iron, and steel.

2. *Insulation*

Properties of insulating materials such as rubber varnishes, plastic compounds, impregnated paper, varnished cloth, tapes, asbestos, and silk.

3. *Resistors and Resistance Measurements*

- (a) An examination and study of resistors used in industrial control apparatus for controlling motors and generators,
- (b) Measurement of resistances connected in series, parallel, or combinations of both; methods of determining the combined resistance.

4. *Induced Currents*

The production of induced currents including the elementary laws of induction relating to direction of induced pressure.

5. *D.C. Generators*

- (a) Elementary laws governing the direction and relative values of induced currents in conductors cutting magnetic fields,
- (b) Simple D.C. shunt-wound generator, parts and their functions,
- (c) Characteristic tests; no load voltage characteristics with variation of field strength (separate constant excitation), variation of terminal voltage with variation of load current (self-excitation).

6. *D.C. Motors*

Operation and control of D.C. shunt, series, and compound-wound motors to determine their characteristics.

7. *Maintenance*

Tests used by journeymen in locating troubles in D.C. motors, generators, and industrial control apparatus; methods of repair.

8. Determination of efficiency characteristics of D.C. generators, and motors based on actual laboratory tests.

9. Industrial control equipment as applied to D.C.

10. An introductory study of the alternating-current generator.

11. *Elementary Industrial Electronics*

- (a) Vacuum Tubes: The diode; construction and testing of standard two-element (diode) vacuum tube; the effect of filament voltage change on plate circuit; the effect of plate-voltage change on plate-current; application of the diode as rectifier; effect of load resistance on output.

The triode: the control action of grid placed between filament and plate; grid voltage, plate current and plate voltage, plate current characteristic curves; information derived from curves with respect to voltage

change, current change, use of tube as amplifier, gain; construction of simple circuits using tube, illustrating operation as an amplifier, grid bias rectifier and control device for relay operation; rectification by means of grid leak and condenser; separate heater and cathode-type tube and comparison with filament type.

- (b) Electron Theory and Thermionic Emission: more detailed consideration of flow of electrons in a body acting under electrical pressure; effect of heat on liberation of electrons; electron-emitting materials; electron emission in vacuum, space charge; Edison experiment to note presence of free electrons in a vacuum (introduction to diode).
- (c) Alternating Current (Qualitative considerations only under this heading): Coil and condenser combined; resonance effect; application in tuning.
- (d) Circuit Elements: Typical circuits such as amplifier circuits, control devices, as used in electronic devices; combining alternating current theory, and vacuum tube theory.

Amplifier types: low frequency; transformer and resistance coupled, push-pull type.

Amplifier: high frequency; the use of tuned grid and tuned plate circuits and gain obtained thereby; precautions needed to avoid undesirable feedback.

Use of series and cathode resistors and by-pass condensers in vacuum tube plate circuits.

Filter circuits: choke input, condenser input and characteristics of each type.

- (e) Oscillation: production and control of oscillator frequency and output in triode tubes; application in test oscillator; general considerations of oscillations in electronic circuits, noting cause of undesirable feedback both regenerative and degenerative.

GRADE XII

(See also Related Courses: **DRAFTING** for Applied Electricity, p. 90; **MACHINE SHOP PRACTICE** for Applied Electricity, p. 95; **WELDING** for Applied Electricity, p. 99.)

A. INSTALLATION AND MAINTENANCE

1. *Circuits*

- (a) Distribution systems in non-metallic, metallic, and rigid conduit circuits for light, heat, and power, such as might be used in modern apartment buildings, and small factories,
- (b) Practical installation of A.C. motors using different types of starters and protective devices commonly used in industry.

2. *Maintenance*

- (a) Locating troubles in generators, feeders, motors, and industrial control apparatus; methods of repair,
- (b) Rewinding: stripping, securing, winding data; rewinding a single-phase and a three-phase induction motor; making all necessary tests before, during, and after rewinding.

3. Specialized services, such as one or more of the following: signal systems, radio service, and armature winding.

B. THEORY AND TEST

1. *Elements of Alternating Current*

Sine wave, frequency, alternation, cycle and effective value of sine wave for voltage, current, power, and flux.

2. *Alternating Current Circuits*

- (a) Inductance, capacitance, reactance, and impedance,
- (b) Application of Ohm's Law to alternating current circuits,
- (c) Current and voltage relations in A.C. series, and parallel circuits,
- (d) Measurement of power, and power factor including the meaning of the terms phase, phase angle, lagging, and leading currents; actual measurement of power in non-inductive, inductive, and capacitance circuits to determine the relation between apparent, reactive, and effective power; actual measurement of power in single, two, and three-phase circuits.

3. *Alternating Current Generators*

- (a) Construction of typical single, and multiphase generators,
- (b) Principles of action for simple, and multiphase distribution of windings; possible combinations of conductors to eliminate copper,
- (c) Parallel operation of generators involving synchronizing by use of lamps.

4. *Alternating Current Motors*

- (a) Experimental study of the revolving magnetic field,
- (b) Comparison of starting characteristics produced by single, and multiphase fields cutting a short-circuited armature winding,
- (c) The construction, and commercial uses of three-phase, squirrel-cage, and wound-rotor induction motors, including an experimental study and calculation of transformer effect, slip, speed characteristics, starting current, full-load current, power factor, torque, and efficiency characteristics,
- (d) The construction and commercial use of single-phase induction motors, including a study of special starting devices, construction, and arrangement of windings, starting currents, torque, speed characteristics, power factor, and efficiency,
- (e) The construction and commercial use of synchronous motors, including a study of starting methods, power factor, speed characteristics, power factor correction, and efficiency.

5. *Losses in Electrical Circuits*

Calculation of wire sizes, copper losses in electrical circuits.

6. *Transformers*

- (a) Construction, principles of action, efficiency, load characteristics, and commercial uses,
- (b) Transformer connections, star, delta, "T" or Scott connection, open delta, for light, heat, and power.

7. *Instruments*

An elementary study of the theory of operation, uses and proper line connections of such instruments and meters used commercially to measure alternating current, voltage, and power, as ammeters, voltmeters, single, and polyphase watt and watt-hour meters, maximum demand meters, and synchrosopes.

8. *Rectifiers*

Types: (a) mechanical, (b) electronic.

9. *Circuit Elements*

Further consideration and selection of topics to depend on nature of course and equipment available: (a) phase inversion circuits, (b) voltage doubler circuits.

Optional Topic

Lighting (domestic, industrial and display):

1. (a) Lighting types, (b) control and equipment, (c) adequate lighting requirement and applications.
2. Insulation values of various materials with particular reference to transformers.

APPLIED ELECTRONICS

GRADE XI

A. THEORY AND TEST

NOTE:—The order of presentation given below is not necessarily the required teaching order. Symbols, both electronic and radio, and methods of establishing correct heater, anode, and grid voltages should be introduced as required. Detail in Sections 2 and 3 below should be introduced incidentally in the course as required.

1. *Vacuum Tubes*

- (a) The diode: construction and testing of standard two element (diode) vacuum tube; the effect of filament voltage change on plate circuit; the effect of plate voltage change on plate current; application of the diode as rectifier; effect of load resistance on output; comparison of crystal detector and diode tube as detector.
- (b) The triode: the control action of grid placed between filament and plate; grid voltage, plate current and plate voltage, plate current characteristic curves; information derived from curves with respect to voltage change, current change, use of tube as amplifier, gain; simple circuits using tube, illustrating operation as an amplifier, grid bias detector and control device for relay operation to be constructed; rectification by means of grid leak and condenser; separate heater and cathode type tube and comparison with filament type.

2. *Electrostatics*

Formation of electrical charges, their attraction and repulsion; composition of electrical charges, the electron theory and its application to static charges; charging by induction, distribution of charges on material, stress lines between charged bodies, discharge from points compared to spheres; electrostatic screening; storage of charge as in condenser and controlled liberation of charge by resistor across condenser; the use of the "time constant" in determining rate of condenser charge and discharge in condenser resistor circuits.

3. *Electron Theory and Thermionic Emission*

More detailed consideration of flow of electrons in a body acting under electrical pressure; effect of heat on liberation of electrons; electron-emitting materials; electron emission in vacuum, space charge, Edison experiment to note presence of free electrons in a vacuum (introduction to diode).

4. *Alternating Current* (qualitative consideration only under this heading)

- (a) Alternating current generator, the sine wave, cycle, frequency, position in the frequency spectrum, amplitude,
- (b) The telephone; transmitter and receiver; conversion of sound to alternating current,
- (c) The induction coil and principles of induced currents with varying D.C. voltage,
- (d) The transformer, showing application of induced currents to conditions in an alternating current circuit; effect of voltage ratio, turns ratio, current ratio with application in power transformer,

- (e) The condenser, its operation and application, the factors affecting capacity of the condenser in filtering and by-passing; reactance change with frequency,
- (f) The coil, operation and application in circuit; self and mutual inductance; how non-inductive coils are wound, and reason for using; coil use in chokes, filters,
- (g) Coil and condenser combined, resonance effect, application in tuning.

5. *Circuit Elements*

Typical circuits such as amplifier circuits, control devices, as used in electronic devices, combining alternating current theory and vacuum tube theory.

- (a) Voltage supply circuits for tube elements including bias systems for the control grid, series resistor and voltage divider systems for plate, screen and other tube elements; the use and operation of by-pass condensers with voltage supply resistors.
- (b) Amplifier types, low frequency, transformer and resistance coupled, push-pull type.
- (c) Amplifier, high frequency, the use of tuned grid and tuned plate circuits and gain obtained thereby; precautions needed to avoid undesirable feedback.
- (d) Comparison of amplifier types, frequency response curves, factors affecting frequency response; extra amplifiers mentioned here—choke coupled, direct coupled.
- (e) Tone control circuits, to reduce high frequency and low frequency content.
- (f) Volume control circuits, location in circuit, taper to use, carbon versus wirebound controls.
- (g) Rectifier types, half-wave, full wave for vacuum tube and dry disc types; crystal rectifiers.
- (h) Filter circuits, choke input, condenser input and characteristics of each type.
- (i) Control circuits, typical circuits to illustrate the application of vacuum tube triode to electronic control.

6. *Oscillation*

Production and control of oscillator frequency and output in triode tubes; application in test oscillator; general considerations of oscillations in electronic circuits, noting cause of undesirable feed-back both regenerative and degenerative.

7. *Test Equipment*

Elementary, simple A.C. and D.C. meter movements, ohmmeter, multimeter, tube tester, test oscillators, construction and principles of operation of each tube; application in servicing electronic equipment, fundamental principles of organized test procedure in locating faults.

B. SHOP COURSE

1. *Bench Work* (to be introduced as required)

The use of the electrical soldering iron; shaping, cutting, drilling light metal chassis; tapping, typical fastening devices, screws, lugs, terminal strips used in electronic work; hardware. Standard operations to be mastered, such as reading instruments, stripping wire, underwriters' knot. Use of common tools: centre punch, chisel, hole punch, fly cutter, file; cabling; dressing screw driver; grinding twist drills. Use of standard test instruments, such as signal generator, tube tester, etc.

2. *The Colour Code*

For condensers, resistors, coils, transformers, to be introduced as required.

3. Construction and use of simple series and shunt-type ohmmeters.
4. Construction and test of simple half and full wave rectifier circuits. Tests to include those for short and open circuits and tests under no-load and load condition.
5. Construction and use of simple condenser tester.
6. Construction and use of simple tube tester.
7. Construction and test of two-stage transformer coupled audio amplifier. Checks to be made with ohmmeter and voltmeter.
8. Construction and test of two-stage resistance capacity coupled audio amplifier. Checks to be made with ohmmeter and voltmeter.
9. The addition of simple volume and tone controls to an amplifier.
10. Construction and test of simple A.C. output meter.
11. Construction and test of simple vacuum tube voltmeter.
12. Construction of a simple relay and insertion in amplifier circuit to illustrate use as a control device.
13. Construction of simple audio-oscillator and test of same for output.
14. Construction of a radio frequency amplifier.

NOTE 1:—The tube base numbering system should be introduced incidentally in the course as required.

NOTE 2:—The projects given above should be introduced at the appropriate time to suit the theory and test course given.

GRADE XII

A. THEORY AND TEST

At the beginning of Grade XII the student should indicate whether he intends to specialize on radio work or industrial electronics. This will determine the percentage of radio assignments that should be given in relation to industrial electronic assignments. The topics listed below are not necessarily in the required teaching order.

1. *Vacuum Tubes*

Further consideration of vacuum tubes:

- (a) Characteristic curves of tetrode and pentode, sharp cut-off and variable types; reasons for use of these tubes,
- (b) Study of tube constants, mutual conductance or transconductance, amplification factor and A.C. plate resistance,
- (c) Consideration of power amplification, the load line, operating point, load matching; power amplification versus voltage amplification,
- (d) Special purpose tubes, construction and operation of double purpose tubes, converter tubes, beam power tubes, electric eye, special rectifiers, vacuum triode use in voltage regulator circuits.

2. *Circuit Elements*

Further consideration and selection of topics to depend on nature of course and equipment available:

- (a) Application of beat note principle, beat note audio oscillator or a super-heterodyne circuit,
- (b) Automatic volume control circuits; A. V. C. filter and time constant involved,
- (c) Phase inversion circuits,
- (d) Inverse feedback circuits.

- (e) Voltage doubler circuits,
- (f) Vibrator power supplies,
- (g) Automatic frequency control as applied to automatic tuning,
- (h) Multivibrator circuit,
- (i) Pulse forming and sharpening circuit.

3. *Alternating Current Theory*

Advanced quantitative considerations. (Use vector diagrams liberally).

- (a) Inductance, calculations of the henry, current lag, coil reactance, inductance and resistance in series, phase relations, impedance.
- (b) Capacitance (the farad), calculations of condenser values, current lead, capacity and resistance in series, phase relations, impedance.
- (c) Frequency-reactance graphs and frequency-impedance graphs for coil and condenser.
- (d) Inductance, capacity and resistance in series and parallel, resonance calculations, selectivity curves.
- (e) Power factor relations, active and reactive current components.
- (f) High frequency effects, distributed capacity and skin effect.
- (g) Transient effects on D.C. and A.C.
- (h) Filters: high, low, band-pass, and band rejection filters; characteristics.
- (i) Elementary transmission line theory, impedance matching, image impedance.

4. *Photoelectric Effects*

Types of cells, vacuum, gas-filled and photronic cells. Construction and principle of operation, characteristic curves and their uses, colour sensitivity, application in control circuits.

5. *Cathode Ray Tube and Oscilloscope*

- (a) Construction and operation of cathode ray tube, electrostatic and electro-magnetic,
- (b) Voltage supplies for cathode ray tube and methods of control,
- (c) Use of electronic switch on cathode ray tube,
- (d) Sweep circuits for cathode ray oscilloscope operation, including synchronizing,
- (e) Applications of cathode ray tube for distortion indication, gain, timing, synchronizing, frequency determination, phase relations, circuit alignment.

6. *A.C. and D.C. motor characteristics, including simple control and starting devices.*

7. *Gaseous Tubes*

- (a) Diodes: characteristics, ionization, gas types, pressure and its effect on firing potential; application as rectifier, regulator and oscillator; the tungar tube.
- (b) Triodes:
 - (1) Characteristics, principle of operation, comparison with vacuum tube, noting non-continuous control characteristic of gaseous triode,
 - (2) Use of gas triode with condenser resistance feedback and D.C. applied to provide timed control of firing,
 - (3) Use of gas triode as switch with D.C. potentials applied,

- (4) Use of gaseous tube as rectifier with A.C. applied to plate and noting effect of variation of grid D.C. potentials,
- (5) Gas tube as rectifier, controlling by changing grid phase relations with respect to plate voltage, also amplitude control,
- (6) Gas triode as controlled oscillator, generating saw tooth and square wave, the multivibrator, the inverter,
- (7) Gas triode as voltage regulator and comparison with pliotron regulators,
- (8) The saturable core reactor and its application in circuits,
- (9) The peaking transformer and its application,
- (10) Examples of industrial control and regulation by thyratrons, ignitrons and pliotron application to motor control, welding control, elevator control, location of defects in objects on assembly line, counting, sorting, grading, measuring within limits, etc.

8. *Test Equipment*

Consideration of circuits used and operation of specialized service equipment:

- (a) A.C. instruments, thermocouple, hot wire, electrostatic, iron vane, rectifier and dynamometer types,
- (b) The vacuum tube voltmeter, application to alternating current, direct current and high resistance measurements,
- (c) Inductance and capacitance bridges,
- (d) Signal tracing methods of analysis.

9. *Specialized Subjects* (optional, if time and apparatus permit)

- (a) Television: scanning methods; camera tube construction and operation; the television signal; synchronizing; F.M. audio amplifier; video amplifier; picture tube operator; sweep circuits; power supplies; T.V. aerials.
- (b) Frequency modulation.
- (c) Microwave transmission and reception.
- (d) X-ray tubes and applications in industrial and medical work.
- (e) Transmitter considerations, circuits, tests, adjusting.
- (f) Antennae, types, characteristics, radiation pattern, wave reflections in the ionosphere.
- (g) Transmission line theory and application in telephone programme links. Impedance matching at R.F.
- (h) Radio broadcast studio technique.
- (i) Facsimile transmission and reception.
- (j) Phonograph pick-ups and arm shapes.
- (k) Microphones, speakers and enclosures.

AUTO MECHANICS

GRADE IX

When feasible, suitable units should be dismantled and assembled.

1. *Chassis*

- (a) Parts: examination and study to obtain the name, purpose, and location of principal parts.
- (b) Specifications: wheel base, spring suspension, steering-gear ratio, tread, and road clearance.

2. *Engines*

- (a) Parts: identification of parts, dismantling, and assembling piston and valve assemblies.
- (b) Principles of the four-stroke cycle; combustion mixtures; properties and danger of carbon monoxide gas and precautions.

3. *Lubrication*

Purpose, simple theory, description, and examination of one system.

4. *Cooling System*

Purpose, simple theory, and examination of one system.

5. *Electrical System*

Simple ignition circuit to be traced and operation observed.

6. *Fuel System and Fuel*

- (a) Names and purpose of units.
- (b) Gasoline: use, precautions in its use, method of storing, methods of extinguishing fires; gasoline prohibited for cleaning purposes.

7. *Fastenings*

Identification of bolts, nuts, cap screws, threads, rivets, washers, cotters; their use and application.

8. *Transmission System*

- (a) Construction and operation of single-plate clutch.
- (b) Transmission: standard positions, speed ratios; mechanical advantages.
- (c) Drive shaft, Hotchkiss and Torque Tube types.
- (d) Differential, purpose.
- (e) Rear axles, types.

9. *Running Gear*

- (a) Front wheel suspension.
- (b) Steering, gear principle.
- (c) Brakes, simple theory.

GRADE X

The course of study in this grade should deal in greater detail with the names, purpose, location, and operation of the principal parts of the modern automobile, and should provide for simple fitting and adjustment during assembly and replacement operations. Running engines are required.

Safety instruction relating to the proper handling of machine and hand tools, gasoline and lubricants, should be emphasized and the dangers of carbon monoxide gas.

1. *The Multiple Cylinder Engine*

- (a) Piston assembly: relative position of pistons in various cylinders, compression ratios and compression pressures, detailed examination of pistons, rings, connecting rods and bearings.
- (b) Crankshaft: relation to stroke, r.p.m.
- (c) Valves: arrangement as to heads, seats, faces, springs, locking, guides, tappets and clearances; timing valves with and without marks; valve lap, lead and lag; relationship of stroke to degrees.
- (d) Horsepower: brief reference to horsepower formula as used for license purposes.

2. *Lubrication*

- (a) Study of a lubrication system for modern automobile engines and chassis; kinds of lubricants, lubrication charts, S.A.E. viscosity ratings, effect of extreme temperatures, filters.
- (b) Operation of oil pumps and relief valves.

3. *Cooling System*

Parts and function; anti-freeze solutions and testing.

4. *Electrical System*

Simple automotive electrical theory.

Identification of component parts for a multiple cylinder engine, including ignition, generator, starter, and lighting circuits, wiring up of the above-mentioned circuits.

5. *Fuel System*

Fuel pumps, filters, carburetor, fuel properties, significance of octane ratings and minor carburetor adjustments.

6. *Transmission System*

- (a) Clutch, detailed examination of a single-plate dry clutch; pedal adjustment.
- (b) Transmission, path of power, relative speeds of crank and drive shafts for different gear shift positions; mechanical advantage, and direction of drive; synchromesh gears.
- (c) Drive shafts, examination of two types; need for universal joint, kinds of universal joints.
- (d) Rear axles, types; more detailed study of differential, including variation in speed of rear wheel to crown gear.

7. *Running Gear*

- (a) Front wheel suspension, types; principal parts including king pins, steering knuckle, bearings, tie rod ends, steering linkage, steering geometry and steering gear reduction.
- (b) Brakes,
 - (i) Mechanical, a study of a mechanical unit.
 - (ii) Hydraulic, a study of operation of master cylinder, and wheel cylinder in actuating brake linkages.

8. *Fastenings*

Identification of machine screws, threads, and sizes.

Identification of metal screws.

9. *Tubes and Fittings*

Types and sizes.

GRADE XI

(See also Related Courses for Auto Mechanics: **DRAFTING**, p. 91; **ELECTRICITY**, p. 95; **MACHINE SHOP PRACTICE**, p. 96; **WELDING**, p. 99.)

To introduce trade work in the Grade XI course, automobiles should be brought in to provide for such work and operations as fall within the scope of this course. The use of specialized testing and fitting equipment should be encouraged in Grade XI.

1. *Engine*

- (a) Further consideration of the general construction of multiple-cylinder engine; cylinder and valve arrangements; types and materials of

crankshaft, main bearings, pistons, piston pins, connecting-rods, valves; valve action details; valve timing.

- (b) Engine lubrication; theory of lubrication; engine oil specifications; details of typical engine lubricating system.
- (c) Engine power; factors of power, calculating engine horsepower; piston displacement; compression ratio; relative pressure.
- (d) Common causes of abnormal engine noises.

2. *Engine Service Operations*

- (a) Checking engine cylinder compression.
- (b) Measuring cylinder wear.
- (c) Fitting connecting-rod bearings, piston pins, piston rings, checking connecting-rod alignment.
- (d) Reconditioning engine valves, valve seats; adjusting valve clearances.

3. *Automotive Electrical Systems*

- (a) General outline of the various systems involved; starter, generator, lighting, and ignition, types, kinds and sizes of automotive electrical wires, cables and terminals; wiring diagrams and symbols.
- (b) Storage battery, general construction and operation of automotive type; testing, and charging storage battery.
- (c) Starter system, purpose of units involved; general construction, and operation of typical starter motor.
- (d) Generator system, purpose of units involved; general construction, and operation of typical automobile generator.
- (e) Lighting system, purpose, and location of various units involved; types, and kinds of automotive lamp bulbs; adjusting headlamps; connecting electrical accessories; purpose, and location of fuses.
- (f) Ignition system, purpose, and location of various units involved in typical automobile ignition system; construction, and types of spark plugs, heat range, cleaning and adjusting spark plugs; adjusting and setting ignition timing; installing, and connecting distributor wires.

4. *Fuel System and Carburetion*

- (a) Properties of gasoline.
- (b) Construction, and operation of typical mechanical fuel pump.
- (c) Further study of principles, and operation of carburetor including dismantling, assembling, and adjusting simple types.
- (d) Cleaning fuel filters and air cleaners.

5. *Transmission Systems*

- (a) Various units involved and relationship to one another.
- (b) Clutch construction, dismantling, identifying and replacing defective parts, assembling, and adjusting.
- (c) Transmission construction, and review of general principles of synchronized gear engagements: dismantling, identifying and replacing defective parts, assembling, and adjusting.
- (d) Rear axle arrangements; types and applications; construction of typical rear axle unit; hypoid gears.

6. *Steering Gears, Wheels and Brakes*

- (a) Further study of camber, caster, king-pin inclination, toe-in; making minor adjustments to wheel alignment.
- (b) Construction of popular types of steering gear; adjusting steering gear and linkage.

- (c) Type of brakes, mechanical and hydraulic operation; general principle of hydraulic brake system; construction of popular types of brake units; removing, relining, replacing, and adjusting typical brake-shoe assembly.

GRADE XII

(See also Related Courses for Auto Mechanics, **DRAFTING**, p. 91; **ELECTRICITY**, p. 95; **MACHINE SHOP PRACTICE**, p. 96; **WELDING** p. 99.)

The work of GRADE XII is to involve diagnosis and servicing of common mechanical and electrical troubles.

1. *Engine*

- (a) Construction, a thorough study of a typical modern automobile engine; standards of accuracy and precision; service work to maintain original standards.
- (b) Identifying parts likely to require replacement; reconditioning or adjustment due to wear.
- (c) Diagnosing engine mechanical defects,
 - (i) Testing for loss of power through leaking valves, pistons, and gaskets.
 - (ii) Testing for loose or worn pistons, worn cylinders, piston pins, and bearings.
 - (iii) Locating causes of overheating.
 - (iv) Locating causes of excessive oil consumption.
- (d) Reconditioning or replacing engine parts not covered in Grade XI, such as cylinders, pistons, and bearings.

2. *Automotive Electrical Practice*

- (a) Use and care of automotive electrical test equipment; diagnosing electrical troubles, systems of elimination.
- (b) Testing storage battery; state of charge and defects; common storage battery troubles; care of the storage battery.
- (c) Remote-controlled starter system, popular types of starter drives; identification of circuits, locating faults in system; testing starter-motor input current and output torque; dismantling and assembling starter motor, and testing internal windings.
- (d) Generator output control methods; third-brush regulation and current and voltage control; testing generator for output; dismantling and assembling generator, and testing internal windings; testing and adjusting voltage regulator.
- (e) Types of ignition systems in common use; common ignition system troubles, proper procedure for diagnosing ignition troubles; testing spark plugs; ignition coil; condenser; spark control methods; checking automatic spark control for accuracy; replacing and adjusting timer contacts; setting ignition timing; synchronizing dual points.
- (f) Types of headlamps commonly employed; sealed-beam units; replacing headlamp units; testing for poor headlamp illumination; headlamp glare; aiming headlamps to meet requirements of law; headlamp control methods; protective devices, fuses; current limit relays.

3. *Fuel System*

- (a) Construction and operation of typical modern carburetor; double-throat carburetors, types and purposes.
- (b) Dismantling and assembling carburetor to discover parts commonly requiring replacement; reconditioning or adjustment; carburetor adjustments and settings.

4. *Engine Tune-up Operations*

- (a) Determining engine mechanical conditions before proceeding with engine tune-up; testing compression; checking valve clearance; inspecting engine lubricant.
- (b) Operations in engine tune-up and importance of correct sequence; valve clearance; battery condition; generator voltage; ignition system units; fuel system units; carburetor adjustments; vacuum test.

5. *Transmission System*

- (a) Common clutch troubles; reconditioning modern clutch; replacing clutch facings and bearings; aligning clutch; clutch adjustment.
- (b) Construction and operation of popular form of synchronized type transmission; troubles likely to be encountered; overhauling of unit.
- (c) Service requirements of universal joints.
- (d) Diagnosing and correcting various rear axle troubles.
- (e) Principles of automatic transmission.
- (f) Gear lubricants for particular requirements.

6. *Running Gear*

- (a) Types of front wheel suspension.
- (b) Common troubles of steering gear, causes and remedies; checking front wheel alignment; steering geometry; adjusting steering gear and linkage on independent wheel suspension.
- (c) Principles of power steering.
- (d) Construction and operation of hydraulic brake system; common troubles of brake system; reconditioning brake cylinders, and bleeding brake systems.
- (e) Removing, replacing and adjusting complete set of brakes.

DRAFTING

GRADE IX

1. *Development of Drafting Skills*

- (a) The use and care of the elementary drafting instruments, T-square, set squares, pencil, scale, compasses, protractor.
- (b) Recognition, through use, of the following: outline, hidden outline, centre line, extension line, cutting plane line, dimension line and arrow head.
- (c) The development of skill in single-stroke freehand vertical capital lettering: alphabet, figures, and fractions; size, slant and spacing, horizontal and slant guide lines. Application in notes and dimensions. (Consider vertical lettering only in this grade, and introduce slanting lettering in Grade X.)

2. *Working Drawings*

- (a) Freehand sketching of orthographic views from pictorial representation and objects to illustrate the correct placement of views on working drawings and the difference between working drawings and picture drawings,
- (b) One-view drawings such as gates, street plan, plot plan, etc. to develop the skills required in using the instruments in 1(a),
- (c) Two- and three-view working drawings, to be drawn from both pictorial drawings and models to scale, such as full, half size or $3'' = 1 \text{ foot}$, of
 - (1) simple rectangular objects,

- (2) angular objects which require straight lines only, such as wedges and tapers,
- (3) objects with curved surfaces involving circles and parts of circles; the locating and dimensioning of circular openings and holes,
- (d) Elementary dimensioning,
- (e) Full sections and half sections; methods of indicating the section and the materials by cross-hatching,
- (f) Geometrical constructions to be included in the project, as required, but not taken as separate items.

3. *Detail and Assembly Drawings*

Detail drawings of simple machine parts to illustrate conventional indications for shop operations such as drilling, threading, tapping, and finishing. (Keep projects simple i.e., Gland and Bushing, Drill Jig, etc.)

4. *Blueprint Reading*

Examining simple drawings and blueprints of shop projects and other objects to learn the sizes, shapes, details, materials, and processes as specified.

GRADE X

1. *Working Drawings*

More advanced problems involving placement and dimensioning of views, revolved sections, symbols of materials and bills of materials. The drawings should be selected from shop projects when suitable. The making of sketch plans before starting the scale drawings should be encouraged.

- (a) Architectural drawing: simple building details such as foundations, floor plans, and wall sections.
- (b) Machine drawing: detail drawings of handles, pulleys, face-plates, couplings, bearings, cranks, glands, fastenings or similar mechanical devices; conventional indications used in plan, elevation, and section views for tapped, blind, bored, countersunk, counter-bored, and cored holes; indications as required for other machine operations and for materials used in machine parts; detail and assembly drawings of simple machines, such as the vise, clamp, and press; National Form Thread and introduction of Thread Profile of Acme, Square, Buttress, B and S Worm, Whitworth.

Familiarization with terms: pitch, depth of thread, major or outside diameter, minor or inside diameter.

2. *Orthographic Projection*

Problems to illustrate the principles of projection: objects with surfaces not parallel to one another, obliquely-cut objects such as frustums of pyramids and cones; incomplete views of machine parts.

3. *Intersection of Surfaces*

Plotting the lines of intersections of cylindrical and rectangular shapes joining at various angles such as on machine parts.

4. *Development of Surfaces*

Developing patterns for rectangular objects; parallel line development of patterns for cylinders (right and oblique cut), two-piece elbows, and scoops.

Radial line development applied to conical and pyramidal shapes; extension of parallel line development to three- and four-piece elbows; developments involving a combination of both methods for pattern layout; allowances for laps and seams.

NOTE: This section should be deferred to Grade XI where a Sheet Metal Shop is operating in the school.

5. *Geometrical Constructions*

Drafting problems involving such layouts as the hexagon, octagon, and pentagon, the division of circles and lines, and the bisection of angles, and lines. (This work shall be included in classroom projects but not done as separate exercises, e.g. nut and bolt for hexagon; number of threads per inch as division of line into any number of parts.)

6. *Blueprint Reading*

Reading drawings representative of the shop work taught in the school and of the local industries. Problems to be arranged to require the preparation and study of lists of the materials and processes indicated on the drawings.

Optional Topics

1. Map or Topographical Drawing: drawing of a land plot from field sketch and notes; indications for topographical features.
2. Tracing and Blueprinting: for the student who makes rapid progress in drafting: inking, tracing, and blueprinting.
3. Further architectural drawing, including simple details such as brickwork, walls, doors, windows, stairs, fireplaces, and kitchen layouts; plans, sections, and elevations of frame construction; details of a small frame structure such as garage, summer cottage, or farm building; conventional representations used on floor plans for details such as windows, doors, electrical outlets, plumbing, and heating.

DRAFTING

(Architectural and Building Construction)

GRADE XI

1. *Building Construction Details*

- (a) Preparation of working details, involving the following elements singly or in combination,
 - (1) Foundations: soil conditions; slab, stepped, offset, plain and reinforced footings; post, pier, column, and wall foundations; foundation waterproofing,
 - (2) Frame wall construction: elements of balloon and braced frames; wood coverings,
 - (3) Masonry wall construction: wall thicknesses; face and backing units,
 - (4) Wood floor construction: joist arrangement, fire-stops, bridging, girders, trimming, floors,
 - (5) Carpentry and joinery: joints, rough and finished carpentry, trim details,
 - (6) Windows: double-hung, casements in wood and metal; mullions, caulking; types for wood and masonry walls,
 - (7) Doors: construction, exterior and interior types and sizes, hardware,
 - (8) Fireplaces: hearth, throat, and flue construction; surround and mantel,
 - (9) Chimneys: flue types and sizes; wall sizes and materials; cleanouts,
 - (10) Stairs: types; open and closed-string construction; tread, riser, and hand-rail relation,
 - (11) Wood roof framing: wood truss construction; elements of the flat, lean-to, hip, gable, gambrel, mansard types; dormers, coverings, cornices,
 - (12) Flashings: for hips, valleys, chimneys, cornices, parapets, soil pipes.

- (b) Layouts and working drawings: incorporation of the foregoing details in the working drawings for a kitchen equipment layout, summer cottage or similar project.
- (c) Some brief exercise in inking should be given.

2. *Building Materials and Methods*

An elementary study of the materials of building construction and the local building by-laws and practices. This study should be carried on concurrently with the preparation of the details outlined in 1, above.

- (1) Wood: drying, shrinkage, defects, sawing, grading, measurement; properties and uses of various building woods.
- (2) Lime: properties; crushed and hydrated; mortar, plaster.
- (3) Portland cement: properties, uses in mortar, stucco, concrete.
- (4) Brick: varieties, uses, bonding types, joints, mortar.
- (5) Stone: classifications, properties and uses of granite, limestone, sandstone, marble, slate, shale; rubble, ashlar, veneers, bonding, waterproofing.
- (6) Concrete: proportions, mixing, placing, curing, forms, uses of steel reinforcing.
- (7) Gypsum products: properties of gypsum; use in plasters, boards, blocks, slabs; dry wall construction.
- (8) Masonry units: concrete, cinder-concrete, silica, clay blocks.
- (9) Flooring: wood, concrete, terrazzo, mastic, tile, linoleum, cork, rubber coverings.
- (10) Glass: varieties, commercial standards, structural glass and block.
- (11) Paint: composition and uses of paints, enamels, varnishes, stains; paints for wood, metal, plaster, concrete.
- (12) Metals: properties and uses of iron, steel, copper, lead, zinc, tin.
- (13) Insulation: types, application and vapor barrier.

3. *Structural Design*

- (a) Elementary treatment of stresses in structures; tension, compression, shear, unit stress.
- (b) Bending moments and shear stress for uniformly distributed and concentrated loads; construction of bending moment and shear diagrams for the above.
- (c) Calculation of wood joist sizes for ordinary uniformly distributed loads; determination of maximum spans for commercial size joists in deflection; pier and footing sizes.

4. *Perspective and Rendering*

- (a) General principles of perspective projection; determination of station point, picture plane, horizon, lines of heights, and vanishing points.
- (b) Problems in angular and parallel perspective applied to architectural details involving rectangular, triangular, and pyramidal solids, curved lines and cylinders.
- (c) Rendering in pencil of simple forms in light and shade; rendering of simple architectural instrumental perspective in pencil.

5. *History of Architecture and Design*

- (a) General outline of the history of ancient building, with emphasis on the Greek and Roman periods, particular attention being given to the use of materials, methods of construction and to the form and proportion of details of these periods which are still in use.
- (b) Freehand sketches or formal drawings of representative details of the various periods.

GRADE XII

1. *Working Drawings*

- (a) Residence plans: preparation of working drawings of a small residence at $\frac{1}{4}$ " scale, complete with details, such as wall sections, windows, main entrance doorway, porches, cornice, bay windows, dormers, kitchen cupboards, staircase, mantel, and interior trim.
- (b) Some exercise in inking.
- (c) Mechanical equipment layouts: piping diagrams for hot-water heating and water-supply systems; duct layout for the heating and ventilating of a small building.
- (d) Structural steel details: working details using standard shapes for steel-framed floor bay, or similar project.
- (e) Surveys: drawing of land plot from notes prepared in field, showing buildings, natural features, levels, linear and angular measurements; measurement of building details.

2. *Building Methods and Materials*

The work of Grade XI extended to include:

- (a) running lines and staking out,
- (b) organization of work and sequence of trades,
- (c) study of plumbing installations including materials and construction of drains, soils, wastes, vents, traps, fixtures, septic tanks, hot and cold water supply, gas piping,
- (d) heating installations; comparison of warm-air and hot-water systems, gravity and forced circulation; gravity or forced-air conditioning, radiant heating; boilers, radiators, pipe and fittings, controls; elements of air-conditioning; fuels; calculations for heat loss, radiation, duct work; insulation—types, points of application,
- (e) electrical work, service entry, switches, distribution, circuit arrangements; armoured cable, non-metallic cable and rigid conduit installations,
- (f) study and preparation of specifications for a small residence covering excavation, masonry, rough and finished carpentry, lathing and plastering, sheet metal and roofing, tile work, painting and glazing, plumbing, heating, and electrical work.

3. *Estimating*

- (a) Approximate methods of estimating building construction by the cubic foot and square foot.
- (b) Consideration of the units of measurement, methods of estimating and pricing for general items, excavation, grading, brickwork, mortar, rough and dressed stonework, concrete, concrete block, waterproofing, rough wood framing, sheathing, siding, shingles, frames and sash, exterior and interior doors, finished carpentry, trim, fittings, wood flooring, linoleum, sheet-metal work, built-up roofing, lathing, plastering, painting, glazing, floor and wall tilework, electric wiring, heating, plumbing, insulation.
- (c) Application of (b) above in taking off quantities from blueprints of an actual job of a small residential or industrial nature.

4. *Structural Design*

- (a) Extension of Grade XI work to calculation from formulae of bending moment and section modulus for uniformly distributed, concentrated, or combined loads.
- (b) Design of steel lintels, and beams in shear; lateral bending, and deflection; design of steel columns.
- (c) Use of hand-books in solution of structural problems.

5. *Perspective and Rendering*

- (a) Extension of Grade XI work to include instrumental perspective of architectural subjects in angular or parallel perspective.
- (b) Use of conventional architectural shades and shadows.
- (c) Problems in rendering using pencil, pen and ink, monochrome, or full colour.

6. *History of Architecture and Design*

- (a) Continuation of Grade XI work in the history of architecture, with emphasis on the mediaeval, renaissance, and modern periods. Materials and methods of construction to be stressed. Freehand or formal drawings of details.
- (b) Consideration of factors in design such as proportion, balance, unity, and scale as seen in historical examples, monumental and residential, or in objects of everyday use.
- (c) Influence of materials, utility, and methods of fabrication in architectural or industrial design.
- (d) Fundamental considerations of residential design and planning: financing, building standards, lot coverage, orientation, individual area planning, etc.

(Since a residence is the simplest economic and social unit through which the teacher is able to draw on the student's own experience as a background, it is suggested that all topics under sections 1, 2, and 6 (b) and (c) be treated as part of one whole unit. The student should apply such considerations to his own problem as far as possible. He should be made aware of the function and scope of the various trades and their inter-relationship as part of the whole.)

DRAFTING (Mechanical)

GRADE XI

(See also Related Courses for Mechanical Drafting: **MACHINE SHOP PRACTICE**, p. 97; **PATTERNMAKING**, P. 99; **WELDING**, p. 99.)

1. *Machine Parts*

Detail and assembly drawings of machine parts or mechanical equipment.

- (a) Instruction regarding machining operations, tolerances, choice, and purpose of materials used, pattern-making and moulding practice, shop terms.
- (b) Machine fastenings: selection of and correct specifications for machine screws, stud bolts, nuts, washers, taper pins, cotter pins, keys and key-seats, woodruff, feather and taper keys; national coarse and national fine threads; acme and square threads; right and left-hand threads.
- (c) Machine fits, A.S.A. standard.
- (d) Full, half, and revolved sections; broken views.
- (e) Drawing of machine parts from notes and sketches prepared from measurements of actual objects; use of measuring instruments.
- (f) Inking, tracing, and blueprinting.

2. *Engineering Curves*

- (a) Practical geometrical layout for such curves as the ellipse, helix, and involute.
- (b) Plotting of curves for cams, uniform motion, harmonic motion, variable motion, quick return motion.
- (c) Applications of levers, cranks, and cams in changing direction of motions; reversing mechanisms.

3. *Development of Surfaces*

(See note in Grade X, Section 4.)

Triangulation method of development for objects such as transition pieces and irregular conical shapes.

4. *Gearing*

The greater part of the time for this topic should be spent on fundamentals of gearing, uses of various gears, and formulae.

- (a) Spur gears: tooth parts; plotting tooth curves by Odontograph tables and arcs of circles; drafting problems involving detail of pinion and spur gear; speed changing.
- (b) Bevel gears, right angle only.

5. *Jigs and Fixtures*

A study of the uses of jigs and fixtures for performing machine operations; layout of a simple jig such as a drilling jig; applications of shop mathematics in determining angles, offsets, and dimensioning.

6. *Auxiliary Views*

Problems to illustrate the principle of projection using the auxiliary view.

7. *Pictorial Drawing*

The use of pictorial drawings expressed in such forms as isometric, cabinet, oblique, perspective.

Introduction of modern pictorial drawing practice.

Optional Topics—in full or in part

1. *Structural Steel*

- (a) Standard structural shapes—introduction to the structural steel handbook.
- (b) Lap and butt joints, types of rivets, bolts and welds.
- (c) Simple structural steel detail drawings, rivet symbols, pitch of rivets, dimensioning, gusset plates, base plates.
- (d) Bill of materials, calculation of lengths for rivets and bolts; preparation of rivet and bolt lists for shop and field work; paints and surface protection for structural steel.
- (e) Methods of assembling and construction. Field Welding.

2. *Gearing*

Gear trains: spur, bevel; racks and pinions, speed-changing problems; calculation of the horsepower transmitted by spur and bevel gears using the Lewis formula.

GRADE XII

(See also Related Courses for Mechanical Drafting: **MACHINE SHOP PRACTICE**, p. 97; **PATTERNMAKING**, p. 99; **WELDING**, p. 99.)

1. *Machine Drawing and Design*

Design of small typical machines such as lathe, drill press, punch press, scroll saw, grinder, shaper.

- (a) Gathering data from catalogues, hand-books, and reference books.
- (b) Calculations of speeds and feeds, and sizes of gears and pulleys; selection of materials; discussion of pattern-making problems and moulding practice; methods of lubrication.
- (c) Shafts and couplings: flange couplings, shaft collars, fluted and splined shafts, universal joints, flexible couplings.
- (d) Bearings: babbitt, bronze, roller, ball.

- (e) Sketching machine parts to determine approximate dimensions; making layout in pencil.
- (f) Detail and assembly drawing, checking, tracing in ink, blueprinting.
- (g) Preparing weight sheets, cost sheets and material shop orders.

2. *Gearing Problems*

- (a) More advanced problems in spur and bevel gears; worm gears; racks and pinions; spiral gears.
- (b) Drafting problems in the layout of such devices as planer reversing mechanism, pawl and click-type ratchets, chain gear or sprockets, gear chains.
- (c) Transmission problems involving gears, shafts and bearings such as a geared winch or other geared drives or mechanisms.

3. *Dies and Die Design*

- (a) Types of dies: blanking, punching, bending and any other type used in the local area.
- (b) Parts of a die set: die shoe, die, stripper plate, guide pins, dowel pins, punch, punch holder, shank, guide-pin bushings, stops; die set materials.
- (c) Layout and drawings for a punching and blanking die set complete with specifications for materials.

4. *Sheet Metal Pattern-drafting*

Problems combining several methods of development of surfaces; triangulation and radial line method applied to such projects as the layout of ventilators, tapered funnel-top, measuring can, layout of cornice and cornice mitres, sheet-metal caps and finials; the development of the sphere and hemisphere using the gore and zone methods.

5. *Strength of Materials*

- (a) Design problems involving elements of strength of materials; simple tension, compression, bearing, direct shear and bending or deflection; unit stress, ultimate stress, elastic limit, safe working stress, factors of safety, use of hand-books to determine physical properties of materials.
- (b) Design of some simple machine such as a hoisting block for a crane, or a simple beam or truss.

6. *Calculation of weights* castings, structural steel, etc.

7. *Drafting Office Routine*

Drafting office organization, filing and routing systems, division of staff duties and responsibilities.

Optional Topic

Structural Steel Drawing

- (a) Graphical solutions for stress diagrams of simple frames such as derrick frames, Pratt and Fink trusses.
- (b) Design of a simple Fink truss complete with calculations for members; use of the structural steel hand-book; the selection of standard shapes; efficiency of riveted joints; applications of mathematics for calculating bevels and accurate layout.
- (c) Bill of materials and weight sheets; use of letter indications and match marks for assembly; erection diagrams.

INDUSTRIAL CHEMISTRY

GRADES XI AND XII

The aim of this course of study is to produce chemical technicians who have a working knowledge of chemical theory and who also have considerable training in technique.

This outline is based on the courses being taught in several vocational schools in the province. None of these schools teaches all of the allied subjects which are listed here and it is to be understood that other allied subjects, not listed, may be substituted. Proximity to a specialized industry may properly affect the selection of topics and the depth of treatment in any school.

Chemistry

1. General Chemistry and Semi-micro Qualitative Analysis.
2. Gravimetric Analysis.
3. Volumetric Analysis.
4. Organic Chemistry.

Allied Subjects

5. Mineralogy.
6. Bacteriology.
7. Photography.
8. Instruments.
9. Glass Blowing.

1. General Chemistry

It is suggested that the basic minimum course should be that outlined for the Grade XIII Departmental examination, in Curriculum S.18. This will allow any student who wishes to do so to write this examination at the end of his course. The laboratory work is usually more extensive than that recommended for the Grade XIII course.

In addition a course in Semi-micro Qualitative Analysis is given in most schools. This is a useful application of the rules and laws of the general course. At the same time lessons are included in the general work to explain the mathematical principles involved in the law of mass action, ionization constant, solubility product, common ion effect, buffers, and pH control.

The mathematical work covers problems in gravimetric analysis, volumetric analysis, the gas laws, specific gravity, and examples of the topics mentioned above under qualitative analysis, as well as the problems mentioned in the Grade XIII course.

2. Gravimetric Analysis

(a) water of crystallization in hydrated barium chloride; (b) barium in barium chloride; (c) chlorine in barium chloride; (d) iron in ferrous ammonium sulphate; (e) silver in a coin; (f) copper in a coin—(electrolysis); (g) nickel in steel; (h) analysis of solder—lead, tin; (i) analysis of limestone—magnesium oxide, calcium oxide, carbon dioxide (absorption), insoluble materials.

Optional or Bonus Topics

- Carbon in steel by absorption of carbon dioxide.
- Carbon dioxide in limestone by ignition.

3. Volumetric Analysis

(a) Standardization of burettes and pipettes; (b) preparation of N/10 sulphuric acid; (c) standardization of N/10 sulphuric acid; (d) preparation and standardization of N/10 sodium hydroxide; (e) estimation of acetic acid in vinegar; (f) preparation of standard 0.1N hydrochloric and oxalic acid; (g) determination of caustic soda and sodium bicarbonate in commercial caustic soda; (h) determination of temporary hardness of water; (i) determination of permanent hardness of water; (j) preparation of 0.1N potassium permanganate and to standardize it with iron; (k) standardization of 0.1N potassium permanganate with sodium oxalate; (l) determination of iron in an unknown ferrous salt; (m) determination of calcium in Iceland spar; (n) preparation of N/10 potassium dichromate; (o) standardization of potassium dichromate using an "inside indicator"; (p) determination of iron in a ferric salt; (q) preparation of standard N/10 iodine solution; (r) preparation of N/10 sodium thiosulphate; standardization against iodine; (s) estimation of chlorine in bleaching powder; (t) estimation of sulphur dioxide in a sulphite.

Optional or Bonus Topics

The iodine number of an oil. (linseed or cottonseed).

Precipitation methods—Volhard method for silver.

4. Organic Chemistry

THEORY

(a) The meaning of organic chemistry. Elements present in organic compounds. Properties peculiar to organic compounds.

Importance of organic compounds.

(b) The valence of carbon. Structural and graphic formulae. Isomerism.

(c) The saturated hydrocarbons. The petroleum industry.

(d) The unsaturated hydrocarbons

(i) alkenes,

(ii) alkynes.

The possibilities for polymerization amongst these compounds and their relation to such plastics as polystyrene.

(e) The alkyl halides: the polyhalogen compounds.

(f) Aliphatic alcohols: the industrial preparation and uses of methyl alcohol and ethyl alcohol; polyhydric alcohols; ethylene glycol; glycerine.

PRACTICE

The detection of carbon, hydrogen, oxygen, nitrogen, sulphur, and halogens in organic compounds.

The determination of melting point as a means of

(i) establishing the purity of a substance,

(ii) identifying an unknown substance.

Production and properties of methane. Experiments with liquid and solid hydrocarbons.

Production and properties of ethylene.

Preparation of iodoform, preparation of ethyl bromide.

Production of ethyl alcohol by fermentation, properties of monohydroxy-alcohols, production of glyptal as a synthetic resin.

THEORY

- (g) Ethers: diethyl ether as an anesthetic; ethylene oxide as a raw material in the preparation of collosolve.
- (h) Aldehydes: the industrial preparation of acetaldehyde from acetylene; special reactions of formaldehyde.
- (i) Ketones: acetone; relationship of ketones to aldehydes.
- (j) Aliphatic monocarboxylic acids: the fatty acid series; production of vinegar: the unsaturated acids.
- (k) Acid chlorides and acids: reagents used in the synthesis of celanese, etc.
- (l) Esters: fats and oils in their relation to the food, soap and paint industries.
- (m) Soaps: their commercial preparation; how they function as cleaning agents; insoluble soaps and their uses; synthetic detergents.
- (n) Hydroxy-acids: optical activity.
- (o) Dicarboxylic acids: the use of cream of tartar, rochelle salt, tartar emetic.
- (p) Amides: urea as a product of metabolism; urea plastics.
- (q) Amines: ethanolamine as an emulsifying agent.
- (r) Carbohydrates: monosaccharides; manufacture of corn syrup; disaccharides; production of cane sugar; polysaccharides; starch; cellulose.
- (s) Aromatic hydrocarbons: benzene and its homologues; the coal tar industry.
- (t) Aromatic nitro compounds: nitrobenzene; aniline in relation to the dye industry; sulphanilimide, acetanilide and related drugs.

PRACTICE

Properties of diethyl ether.

Properties of aldehydes, tests for aldehydes, the detection of a formalin in milk.

Properties of ketones.

Properties of acetic and formic acids.

Properties of acetyl chloride and acetic anhydride.

Preparation of ethyl acetate, experiments with fats and oils.

Preparation of soap.

Properties of oxalic acid, properties of tartaric and citric acids.

Properties of acetamide and urea.

Production and properties of methylamine.

Detection of carbohydrates, experiments with monosaccharides, disaccharides and polysaccharides.

Distillation of coal, preparation and properties of benzene.

Preparation and properties of aniline.

THEORY

- (u) Aromatic oxygen compounds: phenol as an antiseptic, and in the production of bakelite; the cresols as wood preservatives; aldehydes, benzaldehyde, vanillin; ketones, acetophenone; acids, benzoic acid, phthalic acid.
- (v) Dyes: classification according to
 - (i) method of application.
 - (ii) chemical composition.

PRACTICE

- Production and properties of phenol, preparation of aspirin.
- Formation of dye compounds, dyeing of cloth.

5. *Mineralogy*

(a) Introduction, definition, relation to other sciences; (b) rocks or minerals, simple classification of rocks; (c) crystals—systems, simple forms, laws of crystallization; (d) physical properties of minerals; (e) classification of minerals, outstanding physical properties of a few common minerals in each group; (f) identification of minerals from systematic chart; (g) rocks (more complete classification) and rock structures; (h) geological eras and periods and local formation; (i) ore deposits and mining terms; (j) economic uses of minerals: abrasives, refractories, pigments and decorative materials, ceramics.

6. *Bacteriology*

(a) scientific terms; organisms included in a study of bacteriology; (b) the use and care of the microscope; (c) the structure and function of living cells; (d) osmosis and its importance to living cells; (e) dialysis and its importance to living cells; (f) isotonicity of solutions, applications; (g) morphology of moulds: structure, growth, reproduction; (h) economic importance of moulds, antibiotics; (i) yeasts: morphology, structure, growth, reproduction; (j) economic importance of yeasts; (k) the chemistry of fermentation; (l) the wine industry: types of wines; (m) a visit to a winery; (n) the cultivation and observation of micro-organisms; (o) methods of sterilization; (p) the uses and preparation of culture media; (q) pure culture methods in bacteriology; (r) distribution counts of micro-organisms; (s) morphology of bacteria: rickettsias, viruses; (t) simple bacterial stains: identification of types; (u) a study of growth characteristics in pure culture; (v) the isolation of micro-organisms; (w) calibrating a microscope; (x) bacterial water analysis.

7. *Photography*

(a) Mixing developer and fixer; (b) developing the negative; (c) printing by contact; (d) cameras and camera values; (e) film and film speed; (f) photoelectric effect; (g) enlarging; (h) copying; (i) mounting pictures; (j) papers: contact, kodabromide; (k) lenses: laws of light, "f" values, depth of field; (l) filters and filter factor; (m) special formulae, fine grain, etc; (n) light and shadow effects, lighting; (o) portrait making; (p) slide making; (q) intensifying; (r) reducing; (s) flash pictures; (t) dodging.

8. *Instruments*

The use and maintenance of instruments; a study of the manufacturers' instructions and discussion of the physical or chemical laws involved.

(a) the pH meter; (b) the titrimeter; (c) the Parr bomb; (d) the photoelectric colorimeter; (e) Nessler tubes and colorimetric analysis; (f) viscosimeter; (g) chainomatic balance; (h) polarimeter; (i) microscope: high-power technique, measuring technique; (j) refractometer.

9. *Glassblowing*

(a) lighting and care of the torch; (b) spindle; (c) gathering and bending; (d) flame annealing; (e) splicing; (f) splicing unequal sizes; (g) T and Y joints; (h) internal seal; (i) terminal bulb; (j) medial bulb; (k) electrodes; (l) fixed position splice; (m) glass spinning.

MACHINE SHOP PRACTICE

GRADE IX

1. *Hand Tools and Bench Work*

- (a) Trade description of such tools and equipment required for this course as soft and hard hammers, chisel, punch, file, hand hack-saw, taps and dies, and vise.
- (b) Operations such as sawing, use of hammer and chisel, filing, riveting, abrasive cloth and polishing, use of steel letters in marking, threading (taps and dies), edge and flat bending and forming.

2. *Layout Work*

- (a) Coating of metal surfaces (copper sulphate, chalk, layout dye) to facilitate layout.
- (b) Use of steel rule, square, dividers, scribes, hermaphrodite calipers, and punch in laying out work from blueprints or drawings; centering work for drilling, and use of surface gauge.

3. *Machine Operations*

- (a) Lathe
 - (1) Identification of main parts only, such as headstock, tailstock, faceplate, centres, bed, carriage, and controls.
 - (2) Setting up work in machine, side facing, parallel turning, turning to a shoulder, grooving, use of calipers in turning to size, knurling, taper turning by offset method, filing and polishing, use of chucks, and end facing of work held in a chuck; lubrication of machine.
- (b) Milling Machine
 - (1) Identification of main operative parts.
 - (2) Plain milling.
- (c) Drill Press
 - (1) Identification of main operative parts.
 - (2) Fastening in chuck.
 - (3) Centre punching of location for drilling, securing material in vise or V-block, sizes of drills and method of fastening in chuck, use of cutting compounds, precautionary measures to prevent damage to table and vise.
 - (4) Drawing holes to a desired location, countersinking, drill jig.
- (d) Grinder, (Pedestal or Bench): safety precautions and use of goggles, off-hand grind to remove hard skin of material, rough grinding to bring material approximately to size.
- (e) Power saw: setting up work, cutting to length, use of cutting compounds.
- (f) Shaper: identification of main operative parts. Plain surfacing.

4. *Hot Metal Working*

- (a) Operation of forge or furnace.
- (b) Heating and working metals, simple forging.
- (c) Simple hardening and tempering, case hardening.

5. *Finishing*

Polishing, flowering, and rust proofing.

GRADE X

1. *Hand Tools and Bench Work*

- (a) Use of different types of blades in the hand hack-saw with a view to proper selection.
- (b) Filing to size with greater attempt at the production of flat surfaces.
- (c) Threading by use of taps and dies.

2. *Layout Work*

- (a) Preparation of metal surfaces to facilitate layout.
- (b) Use of steel rule, scribe, centre punch, calipers, layout plate and surface gauge, combination set.

3. *Measurement*

Micrometer, protractor, gauges, and graduated feed collars.

4. *Machine Operations*

- (a) Lathe: taper turning by means of taper attachment; spotting, centreing, and drilling; filing and polishing; screw cutting—external NATIONAL FORM Thread.
- (b) Drill Press: selection of proper drills, drill sizes, different materials and speeds; use of various cutting agents for different materials; drilling to a depth; countersinking.
- (c) Shaper: additional parts, setting the length of stroke and position of ram, shaping a surface to right angle, sequence of operations for shaping a rectangular block.
- (d) Miller: additional parts, changing arbor and cutter, milling a flat surface, side milling, sequence of operations for milling a rectangular block.
- (e) Grinder: study of abrasives as to properties, selection and use; grinding lathe tool-bits to sample and gauges.

5. *Hot Metal Work*

Forging, drawing, hardening, pack hardening, and tempering.

6. *Elementary Metallurgy*

Shop tests for the distinguishing characteristics of common metals; physical characteristics of ferrous and non-ferrous metals; spark testing.

7. *Fasteners*

An examination of such fasteners as rivets, bolts, cap screws, socket, head screws, and keys for purpose of identification and knowledge of their special uses; metal screws, lock washers, and lock nuts.

8. *Repair Maintenances*

- (a) Belts: care, selection, proper operation, lacing and splicing; power transmission.
- (b) Lubrication: bearings types, grease and oil fittings, and special lubrication required.

GRADE XI

(See also related courses for Machine Shop Practice: **DRAFTING**, p. 93; **PATTERN-MAKING**, p. 99; **WELDING**, p. 99.)

1. *Hand Tools and Bench Work*

- (a) Filing a precision surface: a flat surface; irregular forms requiring a variety of shapes and cuts of files.
- (b) Reaming: parallel and taper holes.
- (c) Portable electric drill.

2. *Layout Work*

Use of precision measuring instruments such as Vernier protractor, Vernier height gauge, angle plate, surface plate and surface gauge, precision VEE block.

3. *Measurement*

Vernier caliper, inside and outside micrometer, depth micrometers, telescope gauges, Vernier micrometers, dial indicators, feller and thickness gauges, profile gauges; care and storage of precision instruments.

4. *Machine Operations*

- (a) Lathe: internal construction of headstock, apron and tailstock; truing a damaged centre, aligning centres, free hand turning to a gauge, cutting right and left hand National Standard Threads; taper turning and fitting to gauges; setting a gear-change lathe; steady and follow rest application, drilling boring and reaming; cutting speeds and feeds for various materials, lathe mandrel, use and care of collets.
- (b) Drill Press: types of drill presses, clamping of irregularly shaped work and practice in drilling and countersinking in various metals; counterboring; reaming; use of drilling jigs; tapping attachments.
- (c) Shaper: machining irregular surfaces; internal keyseating, shaping a keyway, serrating.
- (d) Miller: end milling, plain and side milling; sawing and slitting; use of form cutters and flycutters; direct and plain indexing, and plain milling of squares and hexagons; vertical milling; speeds and feeds; cutting compounds.
- (e) Grinder:
 - (1) Practice in grinding tools, and drills of various forms and sizes.
 - (2) Surface Grinder: names of operative parts, magnetic chuck, demagnetizing, securing work, adjusting feed and stroke, truing and mounting wheels, grinding a flat surface.
 - (3) Portable grinder: grinding lathe centres; external and internal grinding in the lathe.
- (f) Band Saw: name of operative parts, speeds and saws for various materials, mounting blade, adjusting saw guides, aligning blade, and welding blade.

5. *Metallurgy*

S.A.E. metals in common use, alloys, characteristics and application.

GRADE XII

(See also related courses for Machine Shop Practice: **DRAFTING**, p. 93; **PATTERN-MAKING**, p. 99; **WELDING**, p. 99).

1. *Hand Tools and Bench Work*

- (a) Filing and scraping: production of a true and parallel surface; machine slide fitting, production of curved surfaces, bearing fitting.
- (b) Lapping hand: suitable abrasives, preparation and application of abrasives; testing surfaces.

2. *Layout*

More advanced layout work involving tool-makers button, trigonometrical functions and the use of the sine bar, and height gauge.

3. *Measurement and Inspection*

Sine bar and sine plate, gauge blocks, standards, three-wire measuring system, height gauge and dial indicator, master square, use of hardness tester, comparator, and other special gauges.

4. *Machine Work*

(a) Lathe

(1) Eccentric turning.

(2) Screw cutting. Acme and Square, cutting right and left-hand internal threads, multiple start threads, chucking with work being trued by indicator, centering work using the indicator with work on the face plate.

(3) Centre spacing on face plate using tool-maker buttons.

(4) Form tools, set up, and backing-off attachment.

(b) Miller: making various tools, such as hobbs; cutting spur gears; cutting bevel gears; cutting and hobbing a worm gear; helical milling, boring and fly-cutting.

(c) Radial drill Press: further work to develop accuracy and technique; setting up irregularly shaped work, clamping to avoid stresses, jigs for drilling.

(d) Grinder, (i) Cylindrical, (ii) Tool and Cutter, (iii) Surface

(1) Name of operative parts, adjustments and operation. Setting feed controls, parallel, taper, external and internal work.

(2) Name of operative parts, accessories, adjustments and operations, cutter sharpening, cutting and clearance angles. Types of wheels, selection of wheels for shape necessary.

(3) Form dressing wheels, sine chuck, VEE block, magnetic VEE block, magnetic parallels.

5. *Metallurgy*

(a) An elementary study of an experience in the use of the thermocouple and pyrometer.

(b) Examination of sections with a view to determining the granular structure and its corresponding physical characteristics.

(c) Further practice in annealing, case hardening, and quenching.

PRINTING

GRADE IX

1. *The California Job Case and Contents*

Character and purpose of the case.

The lower case letters, plan and reason for arrangement.

The capitals, numerals, punctuation marks, ligatures, signs, spaces, and quads.

2. *The Composing Stick*

Kinds, parts and adjustment; use, care, and posture for setting.

Pulling a proof in the stick.

Distribution from the stick.

Justification; simple flush lines.

3. *Type*

Composition, parts, functions, fontage.

Characteristics of similar letters, how identified, type and print compared.

Point system of sizes and measurements.

Point system as applied to leads, slugs and other material.

4. *Composition*

Spacing, justifying, centering, quadding.

Indention and justification as applied to regular paragraph work.

Poetry, flush, indented, turnovers, quotations.

5. *Proofreading*

Correction of work with elementary introduction to the use of the principal marks and their meanings.

GRADE X

1. *Elementary Composition*

Dumping and tying up: methods, precautions and development of skill.

Pulling proofs on the galley: advantages, procedure, and standard of cleanliness necessary.

Distributing from the galley.

Correcting in the stick and on the galley: general classification of corrections and proper procedure; special corrections, including over-running and leading.

Paragraph composition: rules for lines, indention, general procedure to gain uniform appearance and easy reading; justification.

Punctuation marks and spacing: standard practice for the spacing of the period, comma, hyphen, colon, semicolon, exclamation, question, apostrophe, dash, parentheses, and brackets.

2. *Proofreading*

Symbols, use of symbols in study of a proofread model; assigned proofreading.

3. *Special Composition*

Setting poetry: special indentions, justification, general rules and exceptions.

Numbering sentences: alternate use of numbers and letters.

Setting indentions: review of regular paragraph indention and extension of study to include hanging, half-diamond, squared and diagonal.

Setting numbers: three ways of expressing number; rules for comma, usage and examples of correct usage.

Tabular composition: rules for procedure in setting up a simple example of tabulated form.

Multiple justification: advantages and procedure.

Initial letters: history, purpose, extent of use, rules for use in composition.

Leaders and rules: examples, purpose, procedure for composition.

Borders: purposes, common types, margins, procedure for making butted rule border and mitred border.

4. *The Point System*

Brief history: advantages; units; applications to types and materials.

5. *Book Composition*

A booklet in loose-leaf form introducing the following features of book composition: preliminary pages (title pages, advertising card, copyright, dedication, preface, contents, list of illustrations, introduction, half title); chapter heads, initial letters, running heads, sub-heads, leading, over-running, numbering, tabular forms, multiple justification; use of rules, borders, cutting and mitring machines; indentions, side notes, cut-in notes and concluding pages.

NOTE:—It is intended that "book composition" or some similar project should incorporate all the operations referred to in the course.

6. *The Press*

Brief history, general types, principles of operation, proper care, and general experience in the safe operation of a platen press.

GRADE XI

(See also Related Course: **ART** for Pupils Specializing in Printing, p. 89.)

1. *Study of Materials*

Type faces: classification into basic groups—text, Roman, Italic, Gothic or sans serif, script or cursive; a comparative study of available faces in shop, identifying characteristics.

Roman sub-divided into old style, modern, transitional, antique.

Type sizes: application of point system, fontage, alignment, shoulder depth.

Type series: analysis of possibilities for variety without mixing; small caps and italics.

Type families: development from original face—bolder, lighter, condensed, extended; unity with variety, effects of development on beauty and legibility.

Letter-spacing: examination of typical faces for proper letter-spacing.

Rules, borders, ornaments: brass, machine, foundry; trade practices as to body sizes, fontage, purpose, use, dangers.

Paper: history, sources of materials, processes, kinds, uses.

Inks: kinds, materials, manufacture; fitness for use as to paper, press.

Engravings: line, Ben Day, halftone, wood, wax, and lino.

Plates: electro, stereo and rubber.

2. *Planning a Job*

A thorough study of the steps in planning any piece of job-printing or advertising—analysis of copy, choosing important or salient points, making sketches and making a complete layout.

3. *Job Composition*

A number of jobs to be developed as above, set, proofed, read, corrected, and proofed again. These jobs to consist of many types of business forms and advertising, including school printing. Jobs designed and planned in the related art classes to be completed in the print shop wherever possible.

4. *Press Work* (the platen press)

(1) Feeding: placing stock, fanning out, picking up, placing, removing; cleanliness, safety; causes of faulty work; slip-sheeting.

(2) Care of press: oiling, inking, operating, setting up, cleaning up.

(3) Lock-up: materials, uses, positions, procedure.

(4) Putting job on press: reading order, preparing press, putting form on, precautions, make-ready, checking, O.K.

Progressive acquaintance with, and experience on any other types of press available.

NOTE:—In schools with full equipment and a qualified pressman in charge, a more comprehensive course in press-work is advisable.

GRADE XII

(See also Related Course: **ART** for Printing, p. 89.)

1. *Display*

Definition and history: classification as to medium; newspaper, magazine, direct mail; origin, purpose, development and growth.

Functions: to attract; to interpret; to induce action—modes, methods, devices.

Essential elements: legibility—types, measures, breaks; simplicity—how achieved; unity or purity of style—type faces, grouping, arrangement, consistent treatment.

Planning or designing: analysis, nature of job, nature of business or product, to whom addressed, probable reading conditions, effect of these factors on the design or treatment of the piece; analysis of copy; relative importance or value of parts, choice of dominant and secondary points for display.

Preliminary sketches: experimental pencil work, possible and alternative treatments in design, choice of most promising sketch.

Choosing type faces: factors involved—space, measures, illustrations, copy, medium.

Making the layout: details required—dimensions, margins, borders, rules, lettered lines, blocked masses, illustrations, positions, and specifications.

Principles: harmony; shape and direction, type to paper, materials—type, illustrations, rules, borders, ornaments; tone—grays, blacks, faced, colours.

Contrast: black and white, large and small, different faces, grouping or use of white space, colour; danger of over-emphasis or wrong emphasis.

Proportion: width to length, type area to paper area, margins, parts to whole and to each other, type size to page size; lows, ratios, factors.

Balance and symmetry: points of balance—optical centre, line of golden proportion; kinds of balance—formal, informal; symmetrical or conventional *vs.* modern layouts.

2. *Illustrations*

Kinds: line, Ben Day, halftone, linoleum, rubber, wood.

Choice: for paper, job, conditions.

Placing: position, direction, motion, rhythm.

Reproductions: stereo, electro, nickeltype.

3. *Colour*

Purpose, value, effect, number used.

Display considerations: legibility, making sense, completeness.

Mechanical factors: splitting the form.

4. *Advertisements*

Financial, product, entertainment, travel, chain and departmental store, and general, analyzed as to characteristics and traditions.

5. *Press Work*

The work of Grade XI reviewed and expanded as facilities permit. Practical applications in the actual production of live jobs for school use.

SHEET METAL

GRADE IX

1. *Materials*

Galvanized sheet iron and tin plate: reasons for different coatings on sheet iron, advantages and disadvantages of each coating; types of articles made from each metal; common stock sizes and gauges, comparison of thickness of sheets of different gauges used in the shop.

Solders: common (soft) solder, composition; reasons for different alloys used for solder; uses of common solder and special solders.

Soldering fluxes: purpose and reaction of soldering fluxes with common metals; types of fluxes used on common metals; the use of muriatic acid, sal-ammoniac, soldering paste and resin; making zinc chloride (killed acid).

2. *Hand Operations and Tools*

Laying out: use of squaring, measuring and marking tools; method of laying out from a straight edge and a centre line, use of templates; adding seaming allowances for lap and grooved seams, and reinforced edges.

Cutting: use of straight snips for cutting on straight lines and curved lines; notching and cutting for hinges; use of cutting pliers for wire cutting; care of cutting tools.

Folding and forming: proper use of mallet and setting hammer in forming metal over stakes; use of hollow mandrel, beakhorn or improvised stakes for bending along straight lines in the construction of simple straight-lined objects.

Wiring: allowance required for various sizes of wire used in reinforcing edges; preparatory bends, forming wire, use of mallet and setting hammers for hand wiring; necessary precautions to avoid damaging metal during wiring operations; location for ends of wire.

Grooving: use of hand groovers; seaming allowance required, width, type, and direction of folds on edges to be joined; locking ends for proper alignment of folds; operation of grooving a seam.

Soldering:

(1) Soldering iron: purpose, conductivity of copper, oxidation, tinning a soldering iron.

(2) Soldering: heat required; correct position and movement of soldering iron over a seam; penetration of solder into a seam; fusing solder into a metal.

3. *Machine Operations*

Foot squaring shears: cutting on a line, squaring stock; use of side, back and front gauges; types of material which may be cut in shears; safety precautions.

Adjustable bar folder: types of folds (open, close, and double); setting and locking gauge; use of stops for various angles.

Bending brake: method of operating for bending material in the construction of simple straight-lined objects.

Roll former: feeding metal between rollers, adjusting rollers for tension on metal and for forming metal into cylindrical objects of various diameters.

4. *Sheet Metal Finishes*

Methods of preparing various sheet metals to take protective and decorative finishes.

GRADE X

1. *Materials*

The common properties, uses, limitations, methods of manufacture, approximate unit cost and stock sizes of the common sheet metals, such as black iron, steel, galvanized iron, tin plate, zinc and copper: reference to be made to the action of acids on these metals.

Fluxes: types, special uses, preparation of fluxes for the metals listed above.

2. *Hand Operations and Tools*

Laying out: transferring dimensions from a blueprint or drawing to the sheet metal in preparation for cutting; use of indentations for locating bending lines on reverse side of material; adding seaming allowance for double seams.

Cutting: use of straight and curved snips; shearing with chisel and vise.

Folding and forming: use of bench stakes and tools such as hollow mandrel, blowhorn, conductor or improvised stakes in forming cylindrical and conical-shaped objects.

Riveting: use of rivet sets and punches; weights and sizes of rivets; spacing and punching rivet holes: blind riveting, forming rivet heads.

Soldering: selection of soldering iron, selection of proper fluxes; study of melting points of various solder alloys; proper application of solder to various types of seams.

Double seaming: metal allowance required, preparatory folds, proper stakes, method of turning seam with mallet, drawing metal back from folds, squaring and tightening seams.

Copper work: beating, annealing, pickling, polishing, lacquering or waxing, soldering, tinning, and sweating.

3. *Machine Tools and Operations*

Names of main parts, proper use, adjustments, and precautions to be observed for the foot squaring shears, bending brake, adjustable bar folder, slip roll former, and the wiring, burring, and turning machine.

Operations: folding, locking, wiring, turning and burring of flat and cylindrical work.

GRADE XI

(See also Related Courses: **DRAFTING** for Sheet Metal, p. 94; **WELDING** for Sheet Metal, p. 99.)

1. *Pattern Development*

Parallel line development: two- and three-piece round and rectangular elbows: ordinary tees and Y-branches; simple eavestrough and coping mitres; scoops, scalepans and register boxes.

Radial line development: conical-shaped articles such as funnels, flaring pans, pitched covers, and tapering pails or measures.

Triangulation method of development: irregular shapes such as rectangular flaring pans; simple transition fittings such as square to rounds or ovals.

NOTE:—All patterns developed to be fabricated in metal to actual size.

2. *Seams and Seaming Allowances*

Various types and uses of such seams as standing, double, grooved, Pittsburgh, riveted and lined; the amount of metal required to make each seam; common uses and advantages of each in fabrication and installation.

3. *Hand Tool Operations*

Soldering: forging soldering irons to shapes for various uses; soldering metals such as stainless steel, copper, zinc, and lead.

Tinner's snips: use of various types such as straight, curved, double-cutting and scroll snips; care and sharpening of cutting blades.

4. *Machine Operations*

Adjustable bar folder: adjusting folder for tension on various gauges of metals; width and types of folds.

Bending brake: adjusting for tension and bending on various gauges of metals; using forming attachments for making coves and ogees.

Roll former: adjusting and operating in forming cylindrical, flared and wired objects.

Burring machine: burring flat discs and cylindrical shapes for seaming.

Turning: turning edges of cylindrical and conical-shaped objects for wiring.

Wiring machine: wiring straight and formed edges.

Beading and crimping: for ornamenting, reinforcing, and reducing cylindrical and conical-shaped objects.

GRADE XII

(See also Related Course: **DRAFTING** for Sheet Metal, p. 94; **WELDING** for Sheet Metal, p. 99.)

1. *Pattern Development*

An extension of the parallel line and projection methods of developing patterns for round and rectangular pipe and duct fittings, skylight curbs; common, ridge, hip and jack bars; conductor heads and finials; cornice mitres (face and return); intersections on irregular surfaces.

Radial line development: round and rectangular eccentric tapers, stack heads, rectangular Y's and offsets, guards for machine belts, and gears.

Triangulation: eccentric transition fittings, machine and forge hoods, Y-branches from round pipes of equal and unequal angles and diameters, rectangular Y-branches with different areas for ventilation systems, regular and compound offsets.

NOTE:—All patterns for pipe and duct fittings to entail the use of seams commonly used in the fabrication and assembling of blower and ventilation systems.

2. *Seams and Joints*

Blower and ventilation systems: all seams involved in the fabrication and assembling of ducts, etc., such as riveted, slip double seam, built-up hammered lock, drive cleat, S-cleat, standing seam, and slip lock.

Roofing and ceiling: cross and longitudinal joints for flat lock, standing seam and batten roofing; expansion joints for eavetroughs, box gutters, and roofing types of joints used on manufactured metallic ceiling, roofing, and siding.

3. *Oxy-acetylene Welding*

Care and use of tanks, gauges, hose, torch tips and valves; setting up and assembling outfit; lighting and regulating flame; welding and brazing light sheet steel and small structural shapes used in reinforcing and bracing sheet-metal tanks.

4. *Machine Operations*

A more extensive use of the bending brake in forming eavetroughing, cornice, and copings; the use of special forming attachments for the brake.

A wider use of the small machines (elbow edging and setting down, wiring, turning, and burring) in the fabrication of pipe fittings; adjusting heads for end-play; correct position for various gauges of metal used.

Foot squaring shears: replacing, lining up, and adjusting blades for shearing light and heavy metals.

5. *Hand Operations*

Raising, bumping, planishing, dressing; stretching and shrinking edges.

WELDING

GRADE X

A. OXY-ACETYLENE WELDING

1. *Equipment*

- (a) Colour standards, fittings and thread types; manifold systems; safety precautions,
- (b) Welding torches; low and medium pressure types; use of manufacturers' charts for selecting tip sizes,
- (c) Gases: Properties of oxygen and acetylene, methods of manufacturing oxygen and acetylene; construction of commercial cylinders,
- (d) Regulators: Single and two-stage types; structure and function.

2. *Lighting a Welding Torch*

Opening and closing down an oxy-acetylene welding outfit; types of oxy-acetylene flames, and their effects on mild steels; position and torch movements when welding mild steel; running lines of fusion on thin gauge mild steel; explanation of penetration, and its importance for good welding; use of filler rods to deposit beads on a flat surface; selecting type and size of welding rods.

3. *Types of Welded Joints*

Butt, fillet, and tack-weld corner, edge weld; practical application in using manufacturers' charts to select the correct welding tip size and filler rod size; easy shop methods of testing welded joints.

4. *Bronze Welding*

Evolution of bronze welding from the old speltzer method; materials used, preparation of work; practice exercises on mild steel.

5. *The Oxy-acetylene cutting process*

Elementary explanation of oxy-acetylene cutting; practical use in straight-line cutting of mild steel; types of machine cutting equipment.

B. ELECTRIC ARC WELDING

1. *Classification*

- (a) Energy: direct and alternating current,
- (b) Heating: arc and resistance,
- (c) Electrode: carbon, graphite, metallic and shielded arc.

2. *Safety precautions and equipment*

Shields, screens, clothing, electrical hazards.

3. *Auxiliary Equipment*

Cables for ground and electrode connections, ground plates or clamps and methods of securing, types of electrode holders and methods of using.

4. *Energy Supply*

Simplified explanation of commercial equipment

- (a) direct current generator sets,
- (b) alternating current transformer sets,
applicable to the particular types of machines used in the school shop.

5. *Direct Current Welding*

- (a) Control and operation of D.C. generator, for welding with straight polarity.
- (b) Practice in running straight beads with class E4510 and E4511 electrodes; study effect of arc length and electrode angle.
- (c) Use of E4510 and E4511 electrodes in weaving beads; depositing beads to produce a surface weld in flat position, inclined position, and vertical-horizontal position, plain butt, tee-welds, corner, and lap welds.

6. *A.C. Arc Welding*

(Applicable to those schools equipped with 60-cycle welding transformers.)

- (a) Description and elementary discussion of A.C. welding transformer; setting the welding current on an A.C. welding transformer.
- (b) Using E6020 type electrodes or E6012 type for flat position welding. Exercises similar to section 5B and C.

GRADE XI
(OXY-ACETYLENE AND ELECTRIC ARC)

A. OXY-ACETYLENE WELDING

1. *Advanced Welding Techniques*

- (a) Fusion welding on heavy gauge mild steel; single-vee butt joints in a flat position on $\frac{1}{4}$ and $\frac{3}{8}$ inch plate; fore-hand and back-hand methods,
- (b) Oxy-acetylene gas cutting: theory of cutting; structure and function of the cutting torch; the oxygen lance; cutting techniques, bevel cutting, irregular shapes; using a radius bar for cutting circles; use of manufacturers' charts for selecting cutting tip sizes,
- (c) Expansion and Contraction: effects of expansion and contraction; methods to counteract strains due to contraction on cooling; controlling warping and buckling in mild steel, use of clamps and fixtures,
- (d) Preheating: necessity for preheating; preheating furnaces and preheating torches; localized preheating, examples of localized preheating jobs,
- (e) Welding Cast Iron: composition of cast iron; fusion-welding cast iron; bronze-welding cast iron; malleable iron; necessity for bronze-welding malleable iron; preparing cast iron for fusion-welding and bronze-welding,
- (f) Spark test for steels: practice in determining types of steels by spark test,
- (g) Silver soldering: brief explanation of silver soldering and its applications.

2. *Practice Work*

- (a) Making non-rigid butt joints in mild steel, 10 and 11 gauge,
- (b) Single-vee butt joints on $\frac{1}{4}$ inch mild steel, flat position,
Single-vee butt joint on $\frac{1}{4}$ inch mild steel inclined at 45 degrees,
- (c) Single-vee butt joint on $\frac{3}{8}$ inch plate, fore-hand and back-hand technique,
- (d) Vertical welding on light-gauge mild steel,
- (e) Bronze welding on light-gauge mild steel to produce butt, tee, corner, lap, and edge joints; uses of flux, necessity for tinning,
- (f) Fusion-welding cast iron, single-vee butt on cast iron,
- (g) Bronze-welding cast iron,
- (h) Silver-soldering mild steel; plain butt, and lap joints.

3. *Steels and their uses*

S.A.E. steel classification; use of A.W.S. welding symbols on drawings or blue prints.

4. *Heat-treatment of steels*

- (a) Annealing; normalizing as applied to welding practice; hardening and tempering; case-hardening processes,
- (b) Forge practice; use of the welding torch for heating stock; practice in bending and shaping, as an aid to welding.

B. ELECTRIC ARC WELDING

1. *Power (Optional)*

- (a) Direct-current welding generator: circuit of D.C. generator and component parts; self-excitation and separate-excitation in D.C. generators; Rheostat and current control switches.
- (b) A.C. transformer; A.C. transformer circuit and component parts.

2. *The Electric Arc*

Elementary discussion on how electrical energy is transformed to heat energy; voltage drop across the arc; transference of metal across the arc gap; arc blow; straight and reversed polarity.

3. *Electrodes*

- (a) Sizes and types of electrodes (bare and coated),
- (b) heavily coated or shielded electrodes; action of coating on shielded electrodes; comparison of bare and shielded electrodes; arc welding fluxes; current values for metallic electrodes; A. W. S. electrode classification system; determining polarity by burn-off rate.

4. *Control of current and voltage*

Effects of setting current with voltage constant; effects of setting voltage with current constant; practical experiments to note effects of too low current setting, too high current setting, too low voltage with too high voltage setting; determining correct voltage and current setting and welding speed.

5. *Preparation of Work for Welding*

- (a) Cleanliness; use of chipping hammer and wire brush,
- (b) Provision for expansion and contraction,
- (c) Set-up of parts; tack welding.

6. *Welding Operations*

- (a) Electrode movements; introduction to several weaving movements,
- (b) Depositing single-pass stringer bead to form butt joint in $\frac{1}{4}$ inch plate,
- (c) Depositing $\frac{1}{4}$ inch fillet weld—corner joints, flat position,
- (d) Single-vee butt joint, flat position, two passes on $\frac{3}{8}$ inch plates,
- (e) Multiple beads to form fillet welds on $\frac{3}{8}$ inch plate, flat position,
- (f) Vertical welding on 10 or 11 gauge light-gauge mild steel, downward to produce plain butt joint,
- (g) Vertical weld, downwards to form inside and outside corner joints,
- (h) Down-hand butt weld on $\frac{3}{8}$ inch plate,
- (i) Making down-hand vertical butt weld conforming to Boiler Inspection Branch, Department of Labour (Ontario),

Introduction of Class E6012 electrodes, stressing importance of manufacturers' corresponding classification numbers,

- (j) Vertical welding, upward travel, using single and multiple passes on $\frac{3}{16}$, $\frac{1}{4}$ and $\frac{3}{8}$ inch mild steel plate.

Electrode movements when vertical welding; current values for vertical welding; introduction of class E6010 electrode for vertical welding,

- (k) Horizontal-vertical welding single-pass using E6010 type electrode,
- (l) Use of large size electrodes to run beads without any weaving movement, stringer beads.

GRADE XII

(OXY-ACETYLENE AND ELECTRIC ARC)

A. OXY-ACETYLENE WELDING

1. *Metallurgy for Welders*

Production and properties of iron and steel; iron ores; cast iron; wrought iron; steel processes, Bessemer, open hearth, crucible steel; critical points of pure iron; the effect of the addition of carbon to pure iron; impurities in steel; carbon and alloy steels; stainless steels of the ferritic, martensitic, and austenitic groups; effect of heat on the structure of steel; theory of annealing, hardening, tempering of steel; case-hardening of steel; carburizing and nitriding; effects of welding on the structure of steel; non-ferrous metals; discussion on the properties of some

of the most commonly used non-ferrous metals, aluminum, brass and bronzes, copper, white metals; methods of measuring temperature.

2. *Structural Steel Welding*

Study of structural steel shapes; angle irons, channel iron, I-beams, H-beams; sizes and weights of structural steel shapes; welded joints used in structural steel welding; practice in preparing and welding simple joints in angles, channels, and H-beams; lay out and preparation of angles to form welded frames; use of gusset plates in fabricating structural steel shapes.

3. *Pipe Welding*

Comparison of welded pipe joints and threaded fittings; classification of piping as standard, heavy, extra-heavy; sizes of piping and method of measuring; use of pipe cutters for cutting piping; using the cutting torch for cutting piping; bending piping; types of welded pipe joints.

Practice Work

Laying out templates for welded pipe bends, two-piece 90 degree bend, three-piece 90 degree bend, two-piece 45 degree bend, three-piece 45 degree bend, lateral Wye welded joint, true Wye welded joint, welded Tee joint.

Bronze-welding galvanized pipe; bronze-welding copper piping.

4. *Automotive Welding*

Steels used in automobile construction; advisability of welding automotive parts; precautions when repairing gasoline containers; welding car fenders; bronze-welding car fenders; bronze-welding car bumpers; using reinforcing strip.

5. *Aluminum Welding*

Welding sheet aluminum; preparation of edges for sheet aluminum welding; welding aluminum castings; necessity for preheating aluminum when welding; filler rods used for oxy-acetylene welding aluminum; uses of fluxes when aluminum welding; necessity for removing fluxes after welding; aluminum brazing.

6. *Lead Burning*

Application of lead burning in industry; oxy-hydrogen process; welding lead seams; welding lead piping; use of the air-acetylene torch to join lead; practical applications of lead burning using the air acetylene or oxy-acetylene torch.

7. *Silver-Soldering or Brazing*

Grades of silver-solders and their applications; melting points of silver-solders; fluxes used when silver-soldering; types of metals which may be silver-soldered; joint design for silver-soldering; practice in using wire and strip silver-solders.

Practical Work:

- (a) Silver-soldered butt joint in stainless steel,
- (b) Silver-soldered lap joint in stainless steel,
- (c) Silver-soldered bell-shaped joint in copper tubing,
- (d) Silver-soldered tee joint in copper tubing;
- (e) Silver-soldering band saws.

8. *Brass and Bronze*

Information on the welding of brass and bronze; practice in welding brass and bronze castings.

B. ELECTRIC ARC WELDING

1. *Overhead Welding*

Necessity for overhead welding; technique when depositing overhead multiple beads; weaving technique when depositing overhead beads; using Class E6010 electrodes to make:

- (a) Single-vee butt joint in $\frac{3}{8}$ inch plate using multiple stringer beads,
- (b) Single-vee butt joint in $\frac{3}{8}$ inch plate using multiple weaving passes,
- (c) Single-bevel horizontal-vertical weld in $\frac{3}{8}$ inch plate using multiple stringer bead passes,
- (d) Single-vee horizontal-vertical weld on $\frac{3}{8}$ inch plate using single pass stringer bead in root of joint, and multiple weaving passes on completing beads.

2. *Carbon Arc Welding*

Sizes and current values of carbon electrodes; preparing carbon electrodes for welding; use of filler rods for carbon arc welding; position of carbon electrode and filler rod; making a butt joint in light-gauge mild steel with the carbon arc; making a lap joint in light-gauge mild steel with the carbon arc; cutting with the carbon arc; using class E6010 or similar type electrode for cutting and punching holes in steel plate.

3. *Structural Steel Welding*

Application of the electric arc in structural steel fabrication; advantages of electric arc welding in structural steel fabrication; practical application in the use of electric arc welding in producing joints in structural steel; applying flat, vertical and overhead position welding in structural steel fabrication.

4. *Pipe Welding*

Uses of the electric arc in pipe welding; practice on pipe welding using the electric arc; tests for pipe welders on piping in rotating and fixed position joints, vertical overhead, and horizontal-vertical welds; tests and requirements for welded pressure vessels—Boiler Inspection Branch, Department of Labour, Ontario; practice work, refer to section A-3.

5. *Cast Iron Welding*

Procedure when arc-welding cast iron; use of ferrous and non-ferrous electrodes for arc-welding cast iron; practical repair jobs on castings, using the electric arc; arc-welding automobile cylinder blocks; arc-welding automobile cylinder heads.

6. *Welded Design*

Welded Design, study of castings to determine changing from cast to welded design; strength of cast iron in comparison to steel; redesign of a casting, to change to a weldment; designing an electric motor base; designing a grinder pedestal; use of the oxy-acetylene torch for cutting machine parts.

7. *Hard Surfacing*

Hard-surfacing to increase resistance to abrasion and corrosion; application of hard-surfacing alloys; use of manganese steel electrodes; stellite; grades of stellite and their uses; building up cutting tools with stellite; use of stellite and carbide inserts; using the electric arc, and oxy-acetylene processes on practical exercises in hard-surfacing; hard-surfacing, using other types of hard-surfacing electrodes and filler rods; elementary discussion of powder metallurgy.

8. *Power*

Study of various types of D.C. generators; cross-field excitation, direct-current welding generator; dual continuous-control generator; characteristics of a good D.C. welding generator. A.C. transformers; connecting A.C. transformer to three-phase supply; use of three-phase transformer and three welding regulators; connecting single-phase transformers to balance three-phase supply; motor-driven A.C. welding generators; high-frequency A.C. arc welders.

9. *Additional Processes of Welding*

Rectified A.C. argon arc; heliarc; atomic hydrogen arc-welding; equipment and processes described; thyatron and ignatron controlled automatic spot and seam welders; typical thyatron and ignatron control circuits; thermit welding process; Union-melt process.

10. *Inspection and Testing of Welds*

Definition of terms used in the testing of metals; tensile strength, elasticity, and elastic limit; yield point; ductility; brittleness; hardness; malleability; fatigue; types of tests; preparation of specimens for tensile test; bend tests; free bend and nick bend tests; impact tests, Charpy and Izod impact tests; Vickers diamond pyramid test; microscopic examination of welds; etching fluids used for preparing microscopic specimens; X-ray tests; description of X-ray method of testing metals; work shop tests; preparation of specimens for "Nick-bend" and free bend tests, guided bent test; face bend and root bend; importance of testing welders.

11. *Costs*

Methods of determining costs in welding; job cards; cost cards; weights and cost of welding rods and electrodes; determining pounds of rod per foot of weld; over-head in shops.

WOODWORKING

GRADE IX

1. *Materials*

- (a) Lumber: classification of lumber—open and close grain, general purpose and miscellaneous woods; stock sizes; units of measurements.
- (b) Glues: source, preparation and application,
- (c) Hardware: nails (common and finishing); wood screws—flat, oval and round-head; hinges—butt, strap and tee; various types of catches,
- (d) Finishing materials: elementary supplies; stain, shellac, paint, and enamel.

2. *Hand Tools and Operations*

- (a) Laying out: economical selection of stock; use of try-square, marking gauge, and marking knife,
- (b) Sawing: rip and cross-cut,
- (c) Planing: surfaces, edges, ends; at an angle to grain, chamfering, rounding,
- (d) Chiselling: paring, chamfering, rounding, perpendicular chiselling; cutting a hand mortise; use of mallet;
- (e) Shaping: use of coping and compass saw; use of spokeshave and file,
- (f) Boring: use of brace, hand drill, and various types of boring bits,
- (g) Fastening: use of common and finishing nails, screws, corrugated fasteners, clamp nails; use of various types of clamps,
- (h) Sanding: use of coated abrasives such as sand and garnet paper,
- (i) Sharpening: whetting plane irons and chisels.

3. *Machine Tools and Operations*

The machines must be adequately guarded and the guards must be in place. Operations that cannot be completed with the guards in place must not be attempted by the students.

- (a) Lathe: rough and finish turning to size; shoulder and taper turning; simple beads and curves; face-plate turning; use of calipers and templates,
- (b) Jig sawing: sawing simple scrolls,

- (c) Band saw: use of saw in cutting curves; adjustment of guards,
- (d) Mortiser: vertical mortising,
- (e) Router: use of the hand router for simple moulds.

4. *Finishing*

Preparation and application of stain, shellac, paint, and enamel; application of wax (mission finish); care of brushes.

5. *Trimming*

Applying small knobs, hinges, and catches over a finished surface.

GRADE X

In general, the course in woodworking shall consist of cabinet making. Where time and accommodation permit, and the needs of the local community justify it, the course may be extended to include carpentry and/or patternmaking.

In all projects emphasis should be placed on, (1) the interpretation of drawings, (2) the bill of material, (3) the order of operations, (4) sketching and layout.

A. CABINET-MAKING

1. *Materials*

Lumber: pine, birch, maple, basswood, gumwood, mahogany, walnut, composition board, plywood; three methods of curing (drying), namely, open-air drying, hot-air kiln drying, hot-air steam-jet drying.

2. *Hand Operations*

- (a) The extension and improvement in the use of hand tools as outlined for grade IX,
- (b) Use of block, rabbet, and router planes,
- (c) Grinding and whetting keen-edged tools,
- (d) Preparation and use of fillers for nail holes,
- (e) Veneering,
- (f) Use and sharpening of scrapers.

3. *Machine Tools and Operations*

The proper care, operation and guarding of machine tools should be stressed.

- (a) Cut-off saws: swing and straight-line sawing; cutting material to its rough length, use of stop blocks; setting up the machine,
- (b) Variety saw: operation and adjustment of cut, ripping to width; tenon sawing; cross-cutting; sawing rabbets, dados, plows; taper sawing; types of teeth for ripping and cross-cutting; use of jigs,
- (c) Jointer: operation and adjustment; planing face side and face edge, edge jointing; glue jointing of matched stock,
- (d) Planer: planing stock to finished thickness; planing thin stock; taper planing,
- (e) Band saw: laying out work to avoid waste and for economy of sawing; use of jigs; folding the saw blade,
- (f) Mortiser: hollow chisel mortising, blind and through mortising; use of horns where mortise comes near end of stock,
- (g) Lathe: spindle, face, and chuck turning; turning to a template; sanding turned work; special set-ups,
- (h) Grinder: grinding edge tools; tool angles for planing, cutting, and turning tools,
- (i) Portable Router: use of fence, pilot cutters, veining tools,

- (j) Jig saw: simple forms of cuts for scrolls and joints,
- (k) Sanders: operation and adjustment of drum and belt sanders,
- (l) Boring: use of various types of boring bits; setting up and adjusting.

4. *Finishing*

- (a) Water and oil stains,
- (b) Mixing filler for a natural or pickled finish; use of silex, boiled oil, Japan drier, turpentine,
- (c) Shellacking, varnishing, water and oil rubbing; spiriting off.

5. *Upholstering* (Optional)

Hard-seat covering: use of tow stuffing, muslin covering, leatherette covering; gimping and tacking.

B. CARPENTRY

1. *Materials*

Lumber: classification as to rough work (concrete forms); exterior work such as studding, rafters; outside trim and interior trim such as casing, base-boards. Cost of material.

2. *Hand Operations*

Where feasible, a small structure, or sections of a structure, should be built to include the structural members suggested in this course.

- (a) Operations 2 (a), (b), and (c) from the cabinet course,
- (b) Layout, cutting, and fitting of various joints,
- (c) Knowledge of the framing square graduations and tables,
- (d) Framing: use of the framing square in laying out angles for rafters; the meaning of pitch, roof terminology,
- (e) The identification and use of scribes, trammel points, steel tape, level, plumb-bob, and straight edge,
- (f) Hardware: to identify and fit hardware and wood fasteners.

3. *Machine Operations*

- (a) The use of the necessary machines listed under A, Cabinet-Making,
- (b) Radial arm saw: multiple cuts,
- (c) Portable power tools.

C. PATTERNMAKING

1. *Study of Materials*

- (a) Pattern lumber: pine, mahogany, cherry; characteristics, identification, workability, warp, wind, shrinkage, shake, and wind check,
- (b) Fillets: available kinds, application, and sources,
- (c) Colours and protective materials: classification of colours, pigments; shellac and its qualities,
- (d) Abrasives: types, grades, classification, manufacture, and application.

2. *Planning*

- (a) Machine allowance: signs and normal pattern allowances,
- (b) Draft: normal allowances on general pattern constructions; its application to simple patterns,
- (c) Contraction allowances: purpose of the allowance, introduction of the shrink rule allowances for cast iron and steel,
- (d) Simple core print forms, standard forms and dimensions.

3. *Hand Tools*

Pattern-making hand tools for cutting, measuring, fastening, and assembling; use and care of tools; tool technique and sharpening.

4. *Machine Operations*

The use of the necessary machines listed under A, Cabinet-Making.

5. *Types of Construction*

- (a) Solid and simple built patterns for bench including green and dry sand cores, vertical dry sand cores, attached core prints,
- (b) Turned solid patterns between centres, patterns with core prints for vertical and simple horizontal prints, simple split patterns for the lathe,
- (c) Combination of simple lathe and bench work with and without cores,
- (d) Forming simple type core boxes, square and round; testing; parted core boxes, use of dowel pins, core box proportions.

6. *Foundry*

- (a) Moulding: simple moulding equipment; making two-part mould; procedure in making, ramming, simple venting, pattern removal, finishing, runners and gates, closing; green sand cores formed by pattern; use of simple type cored moulds,
- (b) Casting: preparation of metal, safety precautions, pouring; checking casting.

GRADE XI

CABINET-MAKING

(See also Related Course for Cabinet-making: **DRAFTING**, p. 92)

The Grade X course should be extended to include cabinet fitting and assembling and more advanced work on the machines and wood finishing.

1. *Materials*

- (a) Glues: casein, vegetable, and chemical,
- (b) Upholstery, webbing, burlap, tow, moss sateen, air foam rubber.

2. *Hand Tool Operations*

- (a) The adaptation of various joints to particular types of work; the use and sharpening of hand cabinet scrapers and the scraper plane; setting, jointing, and filing saws (hand and machine); forms for clamping irregularly shaped stock; final cleaning up of assembled stock before applying finish,
- (b) Bill of material: taken from simple furniture drawings.

3. *Machine Tools and Operations*

- (a) Cut-off saw: construction of machine, function of parts,
- (b) Variety saw: construction; use of jigs, set up for cutting a stop groove or dado, taper sawing,
- (c) Jointer: adjustment of tables; cutting tapers; use of stops or jigs,
- (d) Planer: construction of machine; function of parts; planing thin stock; taper planing,
- (e) Shaper: set up; shaping against the collar; use of fulcrum pin; use of yoke (straight board) guide; adjustment of hold down and guards,
- (f) Band saw: sharpening, use of jigs,
- (g) Grinder: selection, care, and dressing; description of grinding wheels; grinding plane irons, gouges,

- (h) Sander: construction and use of discs, spindle, drums, belts, and portable sander,
- (i) Safety precautions: great care to be exercised in stressing the use of proper speeds and feeds, and adjustment of guards; special guards to be used wherever necessary.

4. *Upholstering*

Slip seat construction; use of webbing; webbing stretcher, tow or moss regulator.

5. *Finishing*

- (a) Sponging work: preparation and application of water, acid, oil, and spirit stains,
- (b) Use of pumice and rotten stone in water and oil rubbing; rubbing with brilliantine (combination of pumice and rotten stone in oil),
- (c) Application of polish and spiriting off.

CARPENTRY

(See also Related Courses for Carpentry: **DRAFTING**, p. 92.)

Where feasible a small structure or sections of structure should be erected to include the structural members suggested in the course. Reading and interpreting plans and specifications and taking off quantities of materials should be emphasized.

1. *Bench Work*

- (a) Instruction in the use of such hand tools as the back saw, (stair-maker's dado saw), router plane, level, draw knife, straight-edge, and chalk-line. Layout of porch steps and cellar steps,
- (b) Framing square: laying out of common, hip, and valley rafters, jack rafters; allowance for ridge board, rafter deductions.

2. *Construction*

- (a) Foundations: excavating, wall and footing forms; setting forms in position, separating to obtain wall thickness; basement drainage, basement windows and doors; supporting piers; levelling basement floor,
- (b) Floor construction: setting and levelling sill plates, built-up girders, joists, headers; bridging, stair openings (wells), sub-flooring (straight and diagonal laying), plywood sub-flooring,
- (c) Framing: floor plate, studding, top plate, partition plates and studding, door and window openings; outside and inside sheathing; types and methods of laying commercial insulation; furring, wood, and metal lath; the purpose and method of laying building paper on outside wall,
- (d) Types of Siding: cove (novelty, drop), bevel (clap-board), tongue and groove, V-match, composition (asphalt) siding, asbestos siding,
- (e) Exterior Trim; door and window trim; cornice trim, (soffit, fascia, frieze, bed mould),
- (f) Roof Construction: gable and hip type; roof sheathing; setting purlins and collar ties.

GRADE XI

PATTERNMAKING

(See also Related Courses for Patternmaking: **MACHINE SHOP PRACTICE**, p. 98.)

1. *Study of Materials*

- (a) Pattern lumber: selection, defects, seasoning, grading disposition for strength and resistance to atmospheric changes,

- (b) Special pattern requisites: rapping plates, metal dowels, pattern letters, drawing straps, lifting screws.
- 2. *Planning*
 - (a) Preparation of orders of procedure, sketching, and full-size pattern layout including cores and machine allowances,
 - (b) Machine allowance, for ferrous and non-ferrous metals,
 - (c) Principles of contraction and shrinkage in castings, types of shrink rules,
 - (d) Pattern draft, determination of draft allowances in relation to the casting design; draft as it affects the machining of castings.
- 3. *Hand Tools*

Extension of tool technique; use of higher precision measuring and checking tools such as core box planes, bent-shank chisels and gouges, surface gauges, depth gauges.
- 4. *Machine Tools*
 - (a) Safety rules; lubrication, sharpening, setting, and adjusting cutters and blades; use of jigs and holding devices,
 - (b) Extension of machine tool techniques.
- 5. *Types of Constructions*
 - (a) Patterns with horizontal cores, core print allowances for clearance and overhanging anchorage, attaching core prints,
 - (b) Use of tail prints and core boxes,
 - (c) Parted patterns for bench and lathe; use of dogs, fasteners, and plates; combination of bench and lathe constructions; using core prints to strengthen constructions; proportioning core boxes,
 - (d) Simpler type frame and box construction in pattern and core boxes,
 - (e) Introducing loose-piece features in pattern and core box design; attaching with loose dowels and joints,
 - (f) Face-plate turning, use of supplementary face-plates, attaching devices, toolcuts and positions; design and use of templates; application and layout of turned interior forms; measuring devices, rechucking, cutting speeds,
 - (g) Use of cup chucks and screw chucks in turning shell patterns.
- 6. *Foundry*
 - (a) Moulding flasks, snap flasks, three-part flasks; use of cheeks and bars in flasks,
 - (b) Types and positions of runners, risers, vents, gaggers and core irons,
 - (c) Making three-part moulds, irregular partings, and cored moulds,
 - (d) Core-making: sand and proportions, bonds; baking and inserting cores.

GRADE XII CABINET-MAKING

(See also Related Course for Cabinet-making: **DRAFTING**, p. 92.)

Projects are to be selected that require the general use of cabinet tools. Some special attention is to be given to the construction and use of plywood and the matching and laying of veneer. Some elementary instruction in hand carving should be given and should include the use of veiner, fluter, gouge, and vee or parting tool.

1. *Materials*

A study of foreign and native woods used in the cabinet trade; grades and methods of grading lumber; types of cut or sawn veneers.

2. *Hand Tool Operations and Construction*

- (a) Tables (ends): solid and panel construction assembling,
- (b) Frames, undertops and parting rails in case construction; construction of drawers,
- (c) Gluing, clamping, and squaring case goods,
- (d) Jointing and taping plain veneers,
- (e) Matching, jointing, and taping face veneers,
- (f) Gluing up core, crossband, and face veneer (plywood),
- (g) Veneer press: use of cauls (metal, wax paper, or wax plywood parting pieces used in the press when gluing up to prevent individual units of plywood from sticking together),
- (h) Repairing checks or blisters on veneered stock,
- (i) Cutting and applying an overlay.

3. *Machine Tools and Operations*

- (a) Cut-off saw: fitting, setting, jointing, and filing,
- (b) Variety saw: gumming, setting, jointing, and filing a rip saw; filing a dado saw; cutting concave with offset ripping fence,
- (c) Jointer and Planer: grinding and setting knives,
- (d) Shaper: shaping to form; fluting; knife layout,
- (e) Router: set-up and adjustment; use of pin in routing to a pattern,
- (f) Band saw: fitting and brazing; resawing,
- (g) Belting: methods of joining; principles of drives; principles of proper tracking.

4. *Upholstering*

Box seat construction: springing up; webbing.

5. *Finishing*

- (a) Stains: selection and mixing, highlighting and blending,
- (b) Filler: colouring; shellac cutting and colouring; dull, satin, and gloss finish,
- (c) Preparation of polish,
- (d) Varnish remover; refinishing; repairing (indented) finish.

CARPENTRY

(See also Related Courses for Carpentry: **DRAFTING**, p. 92.)

The course is to include a more advanced study of the operations of Grade XI. Reading of plans, writing specifications, material cost, and a study of local municipal building by-laws are to be included.

1. *Laying out Site*

Use of batter boards; running lines, driving pegs; squaring by use of triangle and equal diagonal methods; levelling by the use of pegs and straight edge.

2. *Bench and Mill Work*

- (a) Fitting a mortise lock, fitting lock striker, necessity and method of reversing action of lock, setting butt hinges, solid and loose pin,
- (b) Construction of a small-scale model of a simple straight open-stringer (string) and of a straight closed-stringer stair; laying out stairs with winders; setting risers, treads, newel post; method of laying out bull-nose tread,
- (c) Method of making window-frames, window-sash; position of stiles, rails, and muntins; storm-sash; making a coped joint.

3. *Construction*

- (a) Sill, joist, and girder positions for brick and frame construction; studding; inside and outside sheathing (butt joint and shiplap),
- (b) Roof terminology; open and box cornice; grades of wood and asphalt shingles, method of laying; valley-cutters and flashing; use of framing square in laying out gambrel roof; dormer framing, (teco connector),
- (c) Scaffolding and roof appliances used in the course of construction.

4. *Interior Trim*

Flooring (heavy and thin type), base-board, quarter-round; door jambs and casing, plinth, panelling and plate rail, picture mould, plain and mantel trim, fitting and nailing, scraping (hand and machine), sanding, seasoning; mitred and coped joints.

PATTERNMAKING

(See also Related Courses for Patternmaking: **MACHINE SHOP PRACTICE**, p. 98.)

1. *Study of Materials*

Specifications for pattern supplies, sources, rules in buying, nomenclature.

2. *Planning*

- (a) Pattern layout to show moulding procedures and machining,
- (b) Special pattern markings such as stop-offs, fillets, and loose pieces,
- (c) Adjustments in design of patterns for machining castings such as addition of lugs and bosses,
- (d) Storing and recording patterns,
- (e) Determine weights of castings from patterns and drawings,
- (f) Importance of keeping pattern layout for future reference.

3. *Hand Tools*

Cutting-tool design and angles; advanced tool technique.

4. *Machine Tools*

- (a) Specifications for machine-tools for woodwork; design of blades and cutters,
- (b) Machine speeds, cutting speeds,
- (c) Special cuts and jigs for machine work,
- (d) Discussion of pattern-making power tools for special work such as milling and gear cutting.

5. *Types of Constructions*

- (a) Box and frame constructions including patterns of shell types built on forms; core boxes of same type having loose-piece features with core prints attached by joints,
- (b) Patterns and core boxes of laminated construction such as ring forms, segmental work, wheel constructions presenting use of tongue joints; rechucking rims of circular section; matched parted patterns; turned core box cavities,
- (c) Formed patterns with irregular parting line; loose flange application with slab core such as offset pipe work,
- (d) Stave construction and turning,
- (e) Sweeps and templates for loam and plaster of paris patterns,
- (f) Master patterns: contractions, finish, metal patterns and working patterns,

- (g) Match plates: wood, metal, cast plates; attaching patterns to plates, forming and disposition of gates and runners; layout for one-sided plates, double-sided plates, irregular parting-line plates; discussion of common types of moulding machines used in plate work.

6. *Foundry*

- (a) Types of flasks: shaped, match plate, crane,
- (b) Use of chaplets: types, securing cores,
- (c) Suspended cores, cake and cover cores, draw backs,
- (d) Use of follow boards and match plates,
- (e) Green-sand moulding with shell patterns,
- (f) Dry-sand moulding, use of sweeps, loam-moulding and core-making.

FARM MECHANICS

GRADE IX

1. *Drawing and Plan Reading*

- (a) Measuring and sketching: simple objects in full scale to include placement of views, representation of visible and invisible surfaces, dimensioning and lettering; scale drawings, elementary geometrical construction and lettering as required,
- (b) Reading blueprints: a study of complete drawings of simple, useful farm or home equipment to assist the pupils in picturing the object, locating dimensions, and estimating the cost.

2. *Woodwork*

- (a) Common hand tools: construction, uses, adjustment, and upkeep,
- (b) Materials
 - (1) Uses and recognition in the rough and the finished state of at least six woods; warping and checking of woods, how caused and counteracted,
 - (2) Identification of nails, wood screws, and other hardware in common use,
- (c) Operations: use of saw, plane, chisel, and try-square in squaring stock to size and making joints such as rabbet, mitre, mortise and tenon; the making of at least three articles useful in the home or garden or on the farm; the study of the tools and construction of the joints to be introduced in the pupils' projects.

3. *Paints and finishes*

Paints for wood, iron, and concrete, home-mixed and ready-mixed paints; preparation of surfaces; the uses of shellac, varnish and wax in finishing; the care of brushes.

4. *Rope Work*

Kinds and grades of rope; uses of rope on the farm; care of rope; common knots and their uses; whipping a rope end, crowning and tucking a rope end; making a short splice, long splice and eye splice.

5. *Belt Lacing*

Leather and fabric belts; care of belts; tools required in belt lacing; making of samples of single lacing and double lacing using cardboard and cord.

6. *Harness Repairing*

Importance of keeping harness in good condition by cleaning, oiling, and repairing at least once a year; tools and materials needed; making a waxed thread and practice in stitching splices; attaching snaps and buckles.

7. *Glazing*

Tools, preparation of putty; value of priming coat on sash; methods of cutting glass; practice in putting glass in new sash or in replacing glass in a broken window.

8. *Pipe-fitting*

- (a) Kinds of pipe: black and galvanized iron,
- (b) Operations: cutting, reaming, threading, sealing joints; use of couplings, elbows, tees, reducers; measuring runs and making layouts.

GRADE X

1. *Drawing and Plan Reading*

Map drawings showing buildings, roads, fences, gates, streams, bridges, culverts, water-lines, tanks, drain tiles, soil areas, drainage direction, existing crops and orchards; working and assembly drawings; drawings of farm objects to include sections and scales.

2. *Woodwork*

- (a) Tool sharpening: use of grindstone, emery wheel, and oil-stone in sharpening common hand tools; practice in jointing, setting, and filing hand saws,
- (b) Construction and repair: construction of two or more articles of use in the shop, in the home or about the farm,

3. *Painting and Finishing*

Materials used in paints, shellac, and varnish, and meaning of terms, pigment, vehicle, thinner, drier; mixing paints and painting for specified conditions of exposure; methods of refinishing floors and furniture; whitewashes for farm use.

4. *Forging and Metal Work*

- (a) Forging simple articles to give a knowledge of forging and tempering; use of hack saw in cutting metal; use of the cold chisel and file in vise work with cold metal,
- (b) Soldering: preparation of soldering iron, selection of fluxes; soldering applied to needs of home and farm,
- (c) Drilling: use of post drill for drilling and counter-sinking; use of taps and dies.

5. *Rope Work* (an extension of Grade IX work).

6. *Farm Machinery*

- (a) Implements: types, uses, care and repair.
- (b) Motor mechanics: dismantling and assembling a four-stroke cycle and two-stroke cycle engine to learn the location, names and functions of the principal parts and events in the cycle; studying automobile parts for an elementary knowledge of the clutch, brakes, transmission and electrical system; performing service jobs such as patching tubes, changing tires, lubricating and making up anti-freeze solutions.

GRADE XI

1. *Drawing and Plan Reading*

- (a) Drawing to scale of rural maps and landscapes showing details,
- (b) Scale-drawing and blueprint reading of plans and elevations to include section and assembly drawings of various types of farm buildings; concrete form work.

2. *Woodwork*

- (a) Tool sharpening: types of finishing stones and files for sharpening tools and implement cutters such as axes, hoes, cultivator points, binder and mower knives; jointing, setting, and filing hand and circular saws,
- (b) Construction and repair:
 - (1) The work of Grade X extended to include more advanced wood-work used in framing construction such as a pinned mortise and tenon joint and a bolted spliced joint,
 - (2) Simple frame construction involving the use of the framing square.

3. *Painting and Finishing*

More advanced knowledge of grades of paints and their application to farm buildings and equipment. The use of stains, fillers, shellac, varnish, pumice, and rotten stone, rubbers and polishes; methods of refinishing floors and furniture.

4. *Forge and Sheet Metal*

Bending, shaping, welding, and tempering operations used in making typical farm articles. Constructing and repairing simple sheet-metal objects.

5. *Farm Implements*

A knowledge of the construction and theory of operation of various types of farm machinery such as binders, pumps, windmills, and engines.

Value of proper housing.

Grades and proper use of lubricants.

Repairs such as replacing guards on cutter bars, sections in blades, adjusting binder knotters, replacing slats and straps on binder canvases.

6. *Concrete Work*

Proportions and methods of mixing.

Construction of wood and metal forms.

Selecting, testing and mixing aggregates.

7. *Pipe Work*

Cutting, threading, fitting, and assembling pipe.

Installation and maintenance of valves and fittings.

8. *Motor Mechanics*

Prepared units and models to be set up for practice operations. Typical service adjustments similar to those suggested here to be planned around the available equipment.

- (a) Engine: removing and replacing gaskets, pistons, connecting-rod assemblies; adjusting valves; examining cylinders, pistons, pins and rings for wear; a study of piston travel, compression and displacement.
- (b) Electrical system: operation, care and minor service jobs involving battery, generator, starter, ignition, and lights.
- (c) Carburetion: principles of carburetion; simple service jobs involving cleaning and adjustment.
- (d) Transmission system: dismantling and assembling clutch, gear box, universal, front and rear axle, springs and wheels.
- (e) Steering and brakes: examination of a typical steering linkage and assembly; types of braking systems, mechanical and hydraulic; adjusting two types of brake shoes.
- (f) Traffic regulations: a study of The Highway Traffic Act and the regulations made thereunder.

FARM MECHANICS

GRADE XII

1. *Drawing and Plan Reading*

Detail drawings of farm appliances; timber roof trusses; culverts. Sketches and working drawings of parts of farm implements from measurements made of the part.

Sheet metal drafting

- (a) Developing patterns for simple sheet-metal devices such as ventilators, T-pipes, and elbows,
- (b) Laying out mitre cuts for eavestroughs, cornices, ridge rolls, and gutters.

2. *Woodwork*

Tool sharpening: grinding, filing, and whetting edge of tools of any shape such as gouges, veining tools, auger bits, twist drills.

Construction and repair

- (a) Roof framing to include the use of the framing square to lay off common, hip, and jack rafters, and straight stairs,
- (b) General maintenance repairs.

3. *Painting and Finishing*

The work of Grade XI extended with emphasis on the preparation of surfaces (new and old).

4. *Forge and Sheet Metal*

Bending, shaping, welding, and tempering operations used in making more difficult farm articles, and in repairing broken parts.

Construction and repair of sheet-metal objects such as tanks, ducts, hoppers, and eavestroughs.

5. *Farm Implements*

Dismantling, assembling, fitting, replacing, and renewing parts of farm machinery such as pumps, windmills, and gears and bearings of implements.

6. *Concrete Work*

Care and theory of operation of concrete-mixing machines. Construction and use of irregular wood and metal forms. Reinforcing and testing concrete.

7. *Auto Mechanics*

An extension of the Grade XI course applied to field maintenance and emergency repairs of tractors, stationary engines, and trucks.

RELATED COURSES

The purpose of the related courses is to give the pupil a general technical background for his specialized subject, and to impress on him the fact that the work of different trades is inter-related. Emphasis should be placed on the theory of the subject, and the pupil should be made to see how the techniques of one trade are dependent on those of another.

Owing to the limited time available for related shop studies, it is suggested that wherever possible standard operations or exercises replace the use of projects as media of instruction. Such operations, however, should be directly applicable to the major subject of the pupil, and where feasible, should be done with tools or equipment common to his trade.

The presentation of instruction should be arranged to include the necessary related information which should be introduced as required with the trade operations.

In the teaching of Drafting as a related subject, general blueprint reading and shop sketching should be an essential part of the course. This should also include the C.S.A. standards, with the latest symbols, the actual functions of shop practices in relation to drafting procedure, and the use of catalogues and reference data.

Close co-operation between the instructors of specialized and related subjects is essential. In some cases, projects can be the co-operative effort of the drafting room and the shops.

ART

RELATED INSTRUCTION FOR PUPILS SPECIALIZING IN PRINTING GRADES XI AND XII

1. *Printing History*

The origin and development of letters. Individual projects, such as

- (a) (1) notes and sketches on the origin and development of letters,
(2) study and sketches of classic and modern manuscripts,
- (b) construction and illustration of a booklet containing research, sketches, and clippings; applying the principles of cover design, layout, margins, title page, etc.,
- (c) creation of classroom display cards on early writing and printing; early printers; historical printing equipment. Making cut-outs of early and modern type faces.

2. *Lettering*

Type styles: old style, transitional, modern.

Classification and characteristics: Roman, Gothic, Italic, script, and text.

Construction: Roman proportion, condensed and extended lettering, single-stroke lettering, representing type faces, selecting and combining types, (Light, medium and bold).

3. *Layout*

Use and purpose.

Collection of sample layouts.

Units of layout: headings, sub-headings, body matter, rules, ornaments, illustration, colour areas, trade-marks.

Construction: a detailed study of the design principles and of the basic forms on which layouts are constructed, balance, proportion, simplicity, beauty, tone, contrast, character, panels, diagonals, margins.

Proportion of the whole and of the units.

4. *Colour*

Basic colour principles: hue, value, chroma, complementaries.

Gathering and classifying colour areas.

Colour theories: Prang, Munsell, Ostwald.

Colour in printing papers and inks.

Colour schemes: tints, shades, seasonal colours, advancing and receding colours.

Gathering samples of colour combinations from printed matter.

5. *Methods of Reproduction*

Study of autographic blocks: lino, woodcuts, wood-engraving, colour blocks.

Designing, cutting, and printing blocks for school printed matter.

Silk-screen methods.

Art requirements and limitations of reproduction.

A brief study of modern printing methods, particularly the relation to colour illustration and layout.

Advertising methods in use to-day.

DRAFTING

RELATED INSTRUCTION FOR PUPILS SPECIALIZING IN APPLIED ELECTRICITY

GRADE XI

This part is to be regarded as a basic unit for all students choosing the electrical option (electronics excepted), regardless of any future specialization. The student's work may be accepted in the various forms, neat free-hand sketches or instrumental drawings.

The drafting room should contain illustrative equipment sufficient for all the basic symbols introduced, and a close co-ordination should exist between studies in this course and those of the major electrical course which the student is following.

The course should include

1. Electrical symbols as required.
2. Residence circuits from architect's plans.
3. Wiring diagram for domestic electric range.
4. Control circuits as for furnaces, water heating, and refrigeration equipment, farm water supply, etc.
5. Installation and control circuits for D.C. motors and generators including starting and field control rheostats, undervoltage and no field protection.
6. Construction of circuit diagrams closely related to the student's studies in the major course.

Option:

In schools where a department of applied electronics has been established the course in related drafting may vary from the foregoing course and should be designed to correlate more closely with studies in electronics.

GRADE XII

The course in electrical drafting for Grade XII should include

1. Interpretation (blueprint reading) of installation circuits and equipment.
2. Construction of drawings involving the basic principles of mechanical drafting as applied to mechanical equipment used in the electrical trade.

A selection of work should be made from such topics as

1. Motor and generator winding and connection diagrams.
2. Installation equipment, diagrams and specifications.
3. Switchboard wiring and mountings.
4. Transformer connections and lighting and power circuits.
5. Industrial control devices and installations.
6. Meter connections and location in circuits.
7. Radio circuits and general electronic control devices and installations.
8. Development of sine waves for current, voltage, and power.

DRAFTING

RELATED INSTRUCTION FOR PUPILS SPECIALIZING IN AUTO MECHANICS

GRADES XI AND XII

1. *Blueprint Reading* (Mechanical and Electrical)

Using automotive manuals, charts, and suitable current automotive literature, instruction material should be selected which is closely related to the major shop course in mechanics and which will give the pupils training in the following:

- (a) Identification of materials and parts by drawing attention to the symbols employed.
- (b) Determination from the drawings of the devices and order of procedure for assembly and dismantling.
- (c) Observation of devices and means used to reduce wear, vibration, etc.; to obtain desired linkages and movement control; to obtain desired mechanical security under normal working conditions (locking devices etc.).
- (d) A study of the drafting principles used in a drawing: symbols; selection of views; use of sections, isometric or oblique projections, other projections; materials employed in fabrication; interpretation of exploded views.
- (e) Use of catalogues and handbooks showing "outline" or "dimensional" drawings of tools and parts.
- (f) Simple blueprint reading tests on general orthographic layout.

2. *Mechanical Drafting*

Using automotive parts, (some aeronautical parts may be included), a series of projects should be planned to develop and maintain a working knowledge of the basic principles of mechanical drafting through drawing construction. The pupils' drawings may be accepted in the form of good working sketches in pencil or instrumental drawings.

Principles: drawing of cams; principles of gearing as applied to automobiles; transmissions; differentials.

3. *Electrical Drafting*

Using electrical equipment common to the automotive trade, projects should be planned to give instruction in the basic principles of electrical drafting

through drawing construction. The pupils' drawings may be accepted in the forms referred to under section 2 above.

Principles: interpretation and representation of symbols as required for the projects selected; construction of circuits in sequence of difficulty.

DRAFTING

RELATED INSTRUCTION FOR PUPILS SPECIALIZING IN CABINET-MAKING

GRADES XI AND XII

Pictorial and working drawings for various pieces of furniture.

Detail drawings for standard parts, drawers, doors, turnings.

Full scale layouts, rods, templates for pieces of furniture and also parts.

Bills of material.

Stock sizes of lumber, how they affect cost and design.

Geometric constructions which apply to cabinetmaking, regular polygons, ellipses, curved parts.

Moulds, the use of scrolls, curves, straight lines, and quirks in moulds for above and beneath eye level.

The study of wood joints, and their relation to design and strength.

A study of furniture sizes, table and chair heights, etc.

Simple architectural blueprint reading and a study of detail drawings of built-in furniture, cabinets, and similar fixtures.

A limited study of

(a) Historical considerations affecting furniture design,

(b) Furniture styles and periods.

DRAFTING

RELATED INSTRUCTION FOR PUPILS SPECIALIZING IN CARPENTRY

GRADE XI

When practicable, drawing of structure or sections that are to be built in the woodwork shop.

Special emphasis to be placed on layout, specifications, dimensions and notes, sketching.

1. *Sections*

Details of foundation, sill, cornice, beam construction, interior partitions bearing and non-bearing partitions.

2. *Working Drawings of Basement Plan*

Showing walls and footings, piers, beams, windows, doors, stairs, chimney, furnace, and heating layout, fuel storage, drainage, electrical layout (switches and outlets).

3. *Working Drawings of First Floor Plan*

Showing walls (exterior and interior); position of joists, windows, doors, stairs, living room, dining room, kitchen, bathroom, bedroom; electrical layout; heating layout, plumbing layout.

4. *Elevations*

Front, rear, right, and left views.

5. *Sections of Building*

Floor levels, grade line, roof pitch.

6. *Details*

Footings, walls, roof, cornice, chimney, windows, doors, steps, stairs, built-in cabinets.

7. *Blueprint Reading*

A study of blueprints obtained from the construction field.

Where cabinet-making is taken as part of the carpentry course, the related drafting should include projects to give practice in making a bill of material, projection, dimensioning, pattern drawing, cutting diagrams as applied to the cabinet-making trade.

GRADE XII

Emphasis to be placed on the building code (legal and application forms, permits and fees), sketching, estimating, constructions.

1. *Plot Plan*

Street line, sewer and water, excavating.

2. *Framing Drawings*

Door opening, window opening, arch opening, floor framing plan, roof framing plan, wall frame.

3. Standard designs of Mouldings and their use.

4. Working drawing and full size sections, double hung frame (check rail), casement frame, exterior and interior door frames.

5. Drawing and detailing small timber truss (Teco connector), laminated truss.

6. A study of blueprints obtained from the construction field.

DRAFTING

RELATED INSTRUCTION FOR PUPILS SPECIALIZING IN MACHINE SHOP PRACTICE

GRADES XI AND XII

This course should include freehand sketching, sectional layouts of details and assembly, pictorial layout drawing, pipe and structural fabrication, mechanical movement, elementary tool design, and the use of handbooks and catalogs.

Projects such as a turnbuckle or some adjusting device involving the use of threads; a machine part, in which two or more unlike metals are held together, and must be shown in section; a lubricator, in section, introducing pipe threads.

Detail and assembly drawing of a simple mechanical mechanism, involving the use of threads to secure and to adjust, types of fasteners, and use of tolerances and fits, e.g., a milling machine vice, a simple drill jig or fixture.

The conventional drawing of a gear; names of gear and tooth parts; development of an involute curve.

A series of wheel hubs to show the use of different keys.

A ratchet and arm actuated from an eccentric; calculating motion.

A fabricated steel part, to show the use of welding symbols.

The drawing of a small gear box. The use of the handbook for data on gears, cams, shaft, and bearing sizes.

The meaning of design terms such as factor of safety, stress, strain, centre of gravity, torque, shear, elastic limit.

The assembly and detail of a progressive piercing and blanking die, a precision pump, an air drill, or a similar tool.

Electrical symbols and layouts commonly found on electronic mechanical machines.

DRAFTING

RELATED INSTRUCTION FOR PUPILS SPECIALIZING IN SHEET-METAL PRACTICE GRADE XI

NOTE:—The drafting room should be supplied with models and stretch outs.

1. *Parallel Line Development*

Two-pieced 45° round pipe elbow, four-pieced 90° round pipe elbow, ordinary tee-pipe (same diameters), inclined branch (same diameters), tee-branch (branch smaller), eavetrough mitre 90° outside, eavetrough mitre 90° inside, eavetrough mitre other angle, eavetrough outlet, rectangular 90° elbow, flat rectangular 90° elbow, double register box, single register box.

2. *Radial Line Development*

Ordinary funnel with collar, roof jacket with flashing, tapered measure with flaring lip, simple roof ventilator, fruit scoop, tapered pipe flat one side.

3. *Triangulation Development*

Rectangular pitched covers, square to rectangle taper on centre, rectangular reversible, round taper concentric, round taper eccentric, square to round taper, rectangle to round taper off centre, roof chimney saddle, oval to rectangle off centre.

4. *Blueprint Reading and Estimating*

NOTE:—All patterns to be developed in the manner employed in good trade practice.

GRADE XII

1. *Parallel Line Development*

Five-pieced 90° elbow side seam, elbow intersecting round pipe, elbow intersecting square pipe, collar intersecting an elbow, inclined branch offset, complete ventilator, offset square pipe, compound offset square pipe.

2. *Radial Line Development*

Round pipe on taper, round pipe tapered elbow, cyclone separator.

3. *Triangulation Development*

Round to ellipse, square to round roof fitting, round to round tapered elbow, square to round tapered elbow, rectangle reversible elbow, unequal Y, two-way bull-head Y, oval to round Y with elbows, two-way Y flat one side, oval to round 90° elbow, double rectangular elbow, three-way Y in line.

4. *Blueprint Reading and Estimating.*

ELECTRICITY

RELATED INSTRUCTION FOR
PUPILS SPECIALIZING IN AUTO MECHANICS

GRADES XI AND XII

A LABORATORY COURSE IN ELECTRICAL THEORY AND TESTING

1. An experimental review of conductors, non-conductors, simple series and parallel circuits, resistance, current and voltage measurement, Ohm's law, electro-magnetic effects and laws as related to and within the range of the automotive field.

2. *Induced currents*

Production of induced currents, including the elementary laws of induction relating to the direction and value of induced pressure with special reference to (1) the automotive ignition coil, (2) magnets, (3) D.C. generator and motor.

3. *Storage battery*

Construction, theory of operation and behaviour characteristics during charge and discharge; care and maintenance with special precautions in handling.

4. *D.C. generator and motor*

Construction, theory of operation, and characteristics of automotive generators and starting motors, and laboratory methods of locating faults; study of characteristics of fan and other auxiliary motors.

5. *Condensers*

A study of the function of capacity in circuits with special reference to the condenser across the breaker points.

6. *Auxiliary automotive electrical apparatus*

Study of construction and theory of operation of electrical gauges, meters, heat indicators, etc.

7. *Voltage and current regulators*

Construction, purpose, and theory of operation; laboratory adjustments and methods of by-passing.

8. *Optional*

Short laboratory course in radio mechanics leading to principles involved in radio installation and minor repairs.

Electronic control of automotive equipment such as headlights and doors.

MACHINE SHOP PRACTICE

RELATED INSTRUCTION FOR
PUPILS SPECIALIZING IN ELECTRICITY

GRADE XI

Operations

1. Bench: layout tools; the selection and proper use of the hand tools common to the electrical trade, such as files, chisels, taps and dies, size of tap drills for various metals, the hand hack saw, the electric hand drill.

2. Lathe: parallel and taper turning; using compound rest and steady rest; selecting feeds for turning and thread cutting; cutting and chasing threads; turning soft metals, such as copper.
3. Grinder (pedestal): sharpening twist drills, chisels, lathe tools.

GRADE XII

1. Bench: improvement in technique and accuracy in bench work; filing, scraping, and fitting bearings or mating parts.
2. Lathe: taper turning using the taper attachment; finish turning in brass or bronze; turning running and press fits; drilling, boring, and reaming; special screw cutting; truing shafts.
3. Grinder (pedestal): sharpening star drill, rawl drill, masonry drill, carbide tipped drill, taps.
4. Milling machine: milling a flat on a shaft; cutting a keyway.
5. Technological information: types of bearings; checking shafts with dial indicator, types and uses of machine keys; classes of machine fits; tolerances and limits, lubricants; ferrous and non-ferrous metals; hardening and tempering steel.

MACHINE SHOP PRACTICE

RELATED INSTRUCTION FOR PUPILS SPECIALIZING IN AUTO MECHANICS

GRADES XI AND XII

Topics should be introduced as required and as the course progresses. Teachers should plan activities in order to make certain that the pupils have a good working knowledge of the following topics: lubrication of machines; cutting lubricants; cutting speeds; thread forms and standards; lead and pitch of screws; letter and number sizes of drills; tap drills; tolerances; marking materials—blue vitriol, prussian blue, soapstone, chalks, etc.; metals—nature and use of irons, steels, brasses, babbitt, alloys; S.A.E. markings of steels; spark test of metals at the grinder; construction and use of hand tools—files, stock and dies, hack-saws, and similar tools.

GRADE XI

Standard Operations

1. Benchwork: use of layout tools; characteristics and uses of hand tools, as file, hack-saw, etc.
2. Lathe: aligning lathe centres; mounting and turning work on an arbour; setting up work in four-jaw independent chuck; squaring a shoulder; parallel turning using micrometers; cutting external threads.
3. Drill Press: drilling speeds and feeds for carbon and high-speed drills; drilling jigs and set-ups; drilling to an accurate layout.
4. Milling Machine: simple indexing for polygon shapes and spur gear teeth.
5. Grinder: sharpening tools, such as chisels, scribes, centre punches; adjusting work rest, hood, and observing safety practices.

GRADE XII

1. Bench work: filing parts to a size and/or to a fit; scraping bearings or flat surfaces; the use of gauges, such as screw pitch, thickness, depth, centre; measuring with the vernier caliper and the inside micrometers.
2. Layout Operations: using layout equipment—parallel bars, combination set, Vee blocks, hook rule, test dial indicator.
3. Heat Treating: hardening and tempering steels; annealing copper tubing.
4. Lathe: advanced operations such as turning and fitting a taper to a gauge; drilling, boring, and reaming in the lathe.
5. Drill Press: more advanced operations involving drilling set-ups, and the use of jigs and fixtures.
6. Milling Machine: operations to involve special feeds and set-ups, such as side milling, cutting keyseats, etc.
7. Grinder: the surface, tool and cutter, and cylindrical grinders; purpose of each; names of operative parts; safety precautions; setting up work; selection of grinding wheels; truing wheels; some simple grinding operations.

MACHINE SHOP PRACTICE

RELATED INSTRUCTION FOR
PUPILS SPECIALIZING IN MECHANICAL DRAFTING

GRADE XI

Operations

1. Bench: use of layout instruments, bench hand tools; working to layout lines or to gauges.
2. Drill Press: the use of jigs and fixtures in drilling flat and cylindrical work in various metals.
3. Lathe: use of three and four jaw chucks; special turning operations; drilling, boring, and reaming, tapping—using the three-jaw chuck; screw-thread cutting.
4. Shaper: vertical and angular shaping; use of clamps for special set-ups.
5. Milling machine: slab milling—horizontal surfaces, external and internal surfaces, with side or face cutter; milling rectangular or hexagonal shaped pieces; straddle milling.

GRADE XII

Operations

1. Bench: layout, using the surface plate; more difficult filing operations to closer standards of accuracy on contour work.
2. Drill Press: drilling to a layout, drawing centres; reaming; boring; tapping; use of jigs.
3. Lathe: turning to close limits; use of the dial indicator; cutting external and internal threads; use of the taper attachment.
4. Milling machine: milling a keyway, grooving, gear cutting, using the vertical milling head.
5. Metallurgy, the theory and practice of: terminology; hardness standards; S.A.E. ratings; metal alloys.

MACHINE SHOP PRACTICE

RELATED INSTRUCTION FOR PUPILS SPECIALIZING IN PATTERNMAKING GRADE XI

1. Technological information: composition and characteristics of metals and alloys used in castings and metal patternmaking; melting points of metals; normalizing and annealing; hardness testing; the effect of blow holes, cold shot, shrinkage, cracks in castings.
2. Benchwork: the use of layout tools and materials; layout, filing, drilling, tapping on different metals; file and scrape a split metal pattern and insert dowel pins; layout of a simple casting, involving different machine operations, to check machine allowance, shrinkage, and work.
3. Machine work: simple operations on the lathe, shaper, drill press, and milling machine. These operations should cover a study of feeds, speeds, cutting tools and depth of cut; machining cored holes, advantages and disadvantages of coring a hole, effect of too little metal for machining and hard castings; coolants for metal cutting; machine lubrication; safety precautions.
4. Special machines; the gap lathe for large diameters; the pedestal grinder—grits, grades, and bonds of grinding wheels.
5. Heating operations: sweating pattern halves together for machining; hardening tool steel.

MACHINE SHOP PRACTICE

RELATED INSTRUCTION FOR PUPILS SPECIALIZING IN PATTERNMAKING GRADE XII

1. Metallurgy: heat recording devices—the thermocouple and pyrometer; seger cones; study of different grades of cast iron after machining to show the granular structure and its corresponding physical characteristics; observation and discussion of parts of machine tools and the reasons for the selection of the materials used in construction; seasoning of castings to overcome warp and wind; methods employed; chilled surfaces on castings, uses, procedure; use of handbooks to determine the physical properties of metals.
2. Machine Parts: an examination of some common machine parts to study their nomenclature, location, and function—base, bracket, boss, apron, rocker arm, bearing cap, braces, bushing, cam, counterweight, cover plate, collar, cylinder, eccentric, flange, gib, housing, link, lug, quadrant, quill, rail, saddle, tongue piece; the use of the following as an aid to casting or machining—fitting strips, fillet, ribs, boss, hub, spigot, cast-slotted holes, taper and parallel gibs, good grade metal for surfaces subject to wear.
3. Bench work: uses of more advanced layout tools; layout and methods of attaching patterns on metal plates; checking castings for size and defects preparatory to layout; bridges used in cored holes as assists in machining; repair methods to remedy casting defects—plugs, brazing, welding.
4. Machine Operations: sequence of operations in machining a casting which requires a variety of machine operations; aids required in castings to facilitate machining—lugs, bosses, etc.; proper draft in cored holes to obviate excessive machining; difficulties encountered where cored hole has shifted or is out of proper alignment; clamping to avoid stresses or distortion; securing work in face-plates, chucks, vises, angle-plates, jigs, or fixtures; machining allowances; trimming metal patterns—uses of portable grinder.

PATTERNMAKING

RELATED INSTRUCTION FOR PUPILS SPECIALIZING IN MACHINE DRAFTING OR MACHINE SHOP PRACTICE GRADES XI AND XII

NOTE:—Suitable projects, or operations on projects, should be selected to give pupils the practical applications of the course.

1. The purpose of patterns, and the interrelationship of patternmaking, foundry, and machine shop operations. What the machine designer should know about these operations.
2. The historical background of patternmaking.
3. Planning: sketching and full sized layout; special machining allowances for different metals; the theory of contraction and shrinkage in castings; the shrink rules; draft allowances in relation to casting design and the effect in the machining of castings.
4. Pattern materials: qualities—white pine, mahogany, walnut, cherry, metal, plaster of paris, clay; uses and applications.
5. Types of patterns: one piece; two-part; split; turned; segmental.
6. Fillets: purpose; types.
7. Pattern finishing (shellac) and identification.
8. Assembly of parts: glueing and nailing, the use of dowel pins in split patterns.
9. Core prints and core boxes.
10. Branches of moulding: green sand; dry sand; loam; metal.
11. Gating moulds: purpose of gates in moulds; types of gates for various metals; skewing gates and risers; pouring basin.
12. Metal patterns: the need for and use of these; how they differ from regular patterns; metals and alloys used in patterns.
13. Die castings: comparison of die and sand castings; advantages and disadvantages, typical articles which may be die cast; alloys used in the casting.
14. Power tools: special uses and operations on power tools, such as lathe and disc sander, which are peculiar to patternmaking.

WELDING

RELATED INSTRUCTION FOR PUPILS SPECIALIZING IN AUTO MECHANICS, MACHINE DRAFTING, MACHINE SHOP PRACTICE, SHEET METAL OR APPLIED ELECTRICITY

NOTE:—The emphasis of the course for pupils specializing in Machine Drafting should be to teach these pupils how welding techniques and practices can be used in machine design.

ACETYLENE WELDING GRADE XI

NOTE:—Suitable projects or operations on projects shall be selected to give pupils the practical applications of the course.

General instructions on the purpose of the course, the care of the equipment, safety precautions, the use of instruction sheets, work assignments.

1. History and principles of oxy-acetylene welding and cutting: first commercial torch; method of producing calcium carbide; discovery of oxygen.

2. Scope of oxy-acetylene process, growth of industry, different processes.
3. Auxilliary equipment and supplies: torches; glasses; cutting machine; filler rods (Hercules, cast iron, bronze, etc.); squares; clamps; pliers; etc.
4. Using the equipment: connecting the apparatus; care of cylinder valves; assembling hose lines regulators and blowpipes; shutting down the equipment; closing the blowpipe needle valve; releasing gas from lines and regulators; table of gas pressure.
5. Care of regulators: need for releasing adjusting screws; tightening of regulator nuts; fibre washers.
6. Types of flames and their temperatures: carburizing; neutral; oxidizing; their approximate temperatures.
7. The different flames in welding: carburizing; neutral; oxidizing (drawings of each).
8. The principles of good welding: fusion; bronze welding; brazing; ratio of gases.
9. The velocities of flame: increase of each gas to change velocity of flame; need for changing tip size when maximum output of gas is reached.
10. Explosive gas mixtures: flashback; backfire; safety precautions; causes.
11. Characteristics of beads: penetration and fusion; proper alignment; appearance.
12. The materials used and procedure in running beads without filler metal.
13. Selection of welding rod and fluxes: proper selection; ferrous rods; non-ferrous rods; fluxes.
14. Importance of oxygen gas: combustion; properties; manufacture; pressure; care of cylinders.
15. Acetylene gas: manufacture; properties; construction of cylinders.
16. How to test welds: purpose; method; results; method of finding per cent of elongation.
17. To butt weld on sheet steel: material; preparation of plates; procedure; results; test.
18. Theory of cutting steel: principles involved; formation of oxides; table of gas pressures.
19. Types of fillet welds: definition; types; convex welds; concave welds; proper leg length.
20. How to run beads without and with filler metal, make a corner weld without and with rod, butt weld on sheet metal, hand-cut straight line cuts, lap weld on steel plates. Testing the above welds.

ELECTRIC WELDING

GRADE XI

1. General instructions: care of equipment; safety precautions in using machines the operation of machines on high voltage, prevention of fires; safety precautions for the operator.
2. To set up A.C. and D.C. units: main supply equipment; ground cable; voltage control; amperage control; polarity switch.
3. History and scope of welding: discovery of electric arc in the first part of the 19th century; important part played by welding during World War II; present-day welding procedures.

4. Proper technique for striking an arc: tapping method; scratching method; arc length; crater; characteristics of beads.
5. Definitions of carbon arc welding, metallic arc welding, inert gas welding, inert spot welding, automatic inert gas welding.
6. Technique of arc welding: unshielded arc; shielded arc; arc length; penetration due to speed of travel and current setting.
7. Joining of beads: the importance of filling in the crater; the proper procedure of striking the arc; running beads in the opposite direction.
8. Elementary electricity: comparison of D.C. current to a water system; A.C. current.
9. Weaving of electrodes: types, use, limitations, angles, heat control.
10. Elementary classification of electrodes: color band; type and current setting; where used; characteristics.
11. Study of penetration, fusion, undercut, overlap, reinforcement.
12. Construction of hand-cutting torches: plan, types, lance, powder.
13. The technique of making fillet welds: preparation of plates.
14. How to run stringer beads, join stringer beads, run beads using a weaving technique, run an edge weld on steel plate, hand-cut straight line cuts, make a fillet lap weld. Tests on the above welds.

ACETYLENE WELDING

GRADE XII

1. Construction of acetylene torches; purpose of the torch; mixing chamber; types of torches.
2. Construction of acetylene cutting torches; purpose; type of metals that can be cut; types of torches; oxygen-lance type; powder cutting.
3. Construction of regulators: working parts, working mechanism, types of regulators, safety.
4. Reconditioning tips: method of straightening tips; cleaning plugged orifices; drilling of orifices.
5. Guided-bend test: appearance of welded specimens; precautions against slag; procedure for cutting plates; method of bending samples; results.
6. Welding and cutting on containers, tanks, and vessels; rules to be adhered to before welding; method of cleaning; precautions to be taken during welding.
7. Multiple welds—pass welding, on groove welds; lap welds; tee welds in flat, vertical overhead positions.
8. Principles of joint design: butt welds; lap joints; tee joints; corner joints; edge joints.
9. Types of steel: low; medium; high; effects during welding.
10. How to circle cut and pierce holes, make a fillet tee weld, butt weld a vee groove, make multiple pass lap and tee welds, run a bead of bronze filler on mild steel, braze weld a butt joint, braze weld cast iron, run vertical beads. Testing the above welds.

ELECTRIC WELDING

GRADE XII

1. Theory of arc welding; how arc is formed; reason for light and dark flashes during welding; ionization of coated electrodes.

2. Study of beading and building up; padding of worn surfaces; shaft-building.
3. Comparison between bare rod and coated electrode: oxidation; lightly coated electrodes; functions of heavy coatings.
4. The study of multiple-pass beads on groove welds, lap welds, tee welds in flat, vertical, and overhead position.
5. Classification of electrodes; A.W.S. numbering system.
6. Principles of joint design: butt joints, lap joints, tee joints, corner joints, edge joints.
7. The proper technique for preparing and testing plates for root-bend and the root-face testing operation.
8. Welding and cutting on container tanks and vessels, method of cleaning, precautions.
9. How to weld in horizontal position: angle of electrodes; current used; speed of travel; overlap precautions.
10. Types of steel: low, medium, and high carbon; effects during welding and after welding; elimination of cracking.
11. Effects of common elements on weldability of steel: manganese; nickel; sulphur; phosphorus.
12. Advanced electricity: A.C. transformers; selenium rectifiers.
13. How to make a fillet tee weld; pad a mild steel plate; pad a mild steel shaft; make a multiple pass weld on a lap and tee joint; weld a single V butt joint; preparation on mild steel using a backing strip; run beads in horizontal position; make a horizontal lap weld; make a horizontal butt joint with and without backing strip. Testing the above joints.



